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AIR FORCE SYSTEMS COMMAND

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

MEASUREMENTS OF THE RADIATED NOISE FROM SAILPLANES

D. L. SMITH
R. P. PAXSON, 1/Lt
R. D. TALMADGE
E. R. HOTZ

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NOTICES

FOREWORD

This research was performed by the Aero-Acoustics Branch, Vehicle Dynamics Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. This effort was initiated under Project 1471 "Aero-Acoustic Problems in Air Force Flight Vehicles", Task 147102, "Prediction and Control of Noise Associated with USAF Flight Vehicles".

The work was performed by Messrs. D. L. Smith, R. D. Talmadge and Lt. R. P. Paxson of the Aero-Acoustics Branch and Mr. E. R. Hotz of the Aerospace Dynamics Branch, during the period of August 1969 to February 1970. Tests were conducted at the Richmond Municipal Airport, Boston, Indiana from 25 August to 25 September 1969.

Appreciation is extended to the Technical Photographic Branch of the Aeronautical Systems Division for providing the theodolites during the tests.

The manuscript was released by the authors in February 1970 as a technical memorandum.

This technical memorandum has been reviewed and is approved.

Howard A. Magrath
HOWARD A. MAGRATH
Director, Vehicle Dynamics Division

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I. INTRODUCTION

The noise associated with a flight vehicle is generated by two distinct type sources: (1) the propulsion system and (2) the aerodynamic noise associated with movement of the vehicle through the atmosphere. The minimum noise will be radiated when the propulsion noise is eliminated.

Measurements were taken of the noise radiated from three sailplanes in order to define the aerodynamic noise and to determine its relation to aircraft size and velocity. This report presents the results obtained from one microphone and relates the overall sound pressure level (SPL)* to aircraft parameters.

Descriptions of the sailplanes that were used are given in Appendix A. Descriptions of the test arrangement, instrumentation, test procedures, and data reduction procedures are given in Appendix B. Appendix B also contains a detailed discussion of the data. Appendix C contains all Tables and Figures.

*SPL is in dB re 0.0002 microbar throughout this report.

II. TEST PROGRAM SUMMARY

The sailplanes used during the tests were the Schweizer SGS 2-32, Schweizer 2-33 and Libelle. The noise was measured at fixed microphone positions on the ground while each sailplane passed over the array at various altitudes and speeds. Theodolite readings were taken in order to accurately determine the sailplane's velocity and altitude. Tests were conducted in the late afternoon and early evening on days when the winds were less than three (3) miles per hour. Ambient noise measurements were made throughout the tests. In addition, two of the sailplanes, the Schweizer 2-33 and Libelle, were flown to a high altitude and passed back and forth over observers to determine at what altitude they could be detected.

III. RESULTS

The overall SPL from those flybys with gross weight variations did not show a consistent trend.

The maximum overall SPL measured from each of the sailplanes can be determined with the specified variation from the following:

Schweizer 2-32	$SPL_{OA} = 60 \log V - 20 \operatorname{Log} R - 21.2$	$\pm$ 7 dB
Schweizer 2-33	$SPL_{OA} = 60 \log V - 20 \operatorname{Log} R - 9.8$	$\pm$ 7.5 dB
Libelle	$SPL_{OA} = 60 \log V - 20 \operatorname{Log} R - 26.6$	$\pm$ 4 dB

where

SPL_{OA} = the overall sound pressure level - dB

V = the sailplane velocity - ft/sec

R = the sailplane altitude - ft

The noise radiated from all the sailplanes can be determined within $\pm$ 6 dB from:

$$SPL_{OA} = 60 \log V + 20 \operatorname{Log} R + 10 \log A - 42.2$$

where A is the estimated turbulent area in ft^2 of the sailplane and the remaining terms are as defined above.

The noise radiated from two of the sailplanes was aurally detected in a reasonably quiet background (approx. 55 dB) at altitudes in excess of 2000 feet. From a detailed analysis of the data, the altitude at which the sailplane would be detected was estimated within 2 to 4 dB.

IV. CONCLUSIONS

The following conclusions were reached.

a. The altitude and velocity of the sailplane measured from flight instrumentation is not of sufficient accuracy to relate the radiated noise to these parameters.

b. The overall SPLs measured in this test indicate that the noise radiated from sailplanes increased as the sixth power of the velocity and directly with the turbulent area.

Appendix A

Description of Sailplane

(All Tables and Figures referenced are contained in Appendix C)

Schweizer SGS 2-32

The Schweizer SGS 2-32 is an all metal, two place, high performance, sailplane built by Schweizer Aircraft Corporation of Elmira, New York. Figure 1 is a picture of the Schweizer 2-32 and Figure 2 is a three view drawing of the sailplane. The specifications of the Schweizer SGS 2-32 are listed in Table I. A NACA 63_3618 laminar flow airfoil is used from the root to 140 inches from the wing tip. From that point the airfoil is uniformly tapered to a NACA 43012A airfoil at the wing tip.

Schweizer 2-33

The Schweizer 2-33 is a two place sailplane built by Schweizer Aircraft Corporation of Elmira, New York. The 2-33 is constructed with all metal wings and ailerons. Basic fuselage construction is of welded chrome-moly seamless tubing with nose fairing of fiberglass. Figure 3 is a picture of the Schweizer 2-33 and Figure 4 is a three view drawing of the sailplane. The specifications of the Schweizer 2-33 are listed is Table I. A NACA 43012 airfoil is used over the entire wing.

Libelle

The Libelle is a single place, high performance sailplane built by Glasflugel GmbH., Schlattstall, Wttbg., West Germany. The Libelle fuselage is of fiberglass monocoque (not sandwich) construction and has a retractable landing gear. The wing is constructed of two-piece fiberglass and balsa sandwich skins. A Wortmann laminar flow airfoil is used. Figure 5 is a picture of the Libelle and Figure 6 is a three view drawing of the sailplane. The specifications of the Libelle are given in Table I.

Appendix B

Experimental Apparatus, Procedures, and Results

(All Tables and Figures referenced are contained in Appendix C)

Test Setup

Figure 7 is a drawing of the Richmond Municipal Airport, Boston, Indiana which gives the location of the microphone array and the two theodolite stations. A sketch of the microphone array including microphone identification numbers and location of the weather station is presented in Figure 8. The microphones were mounted five feet above the ground on aluminum poles with the microphone diaphragm parallel to the ground. Wind screens were used on all microphones. Figure 9 shows the installation for microphone number 1. Similar installations were made at each microphone location.

Instrumentation

A block diagram of the data acquisition system is shown in Figure 10. The signals from the microphone-cathode follower systems were fed into high input impedance line driver amplifiers. The low impedance outputs from the amplifiers were fed through 1500 foot land lines to voltage amplifiers located in an Air Force Flight Dynamics Laboratory Mobile Data Acquisition Van described in Reference 1. The outputs from the voltage amplifiers were fed directly to a Honeywell 7400 FM magnetic tape recorder. A microphone was used in the van to record on tape all pertinent data during the sailplane flyby. The output from a Multitech Mark II portable anemometer was fed into the van via a 1500 ft. line and terminated in a weather data instrument panel and in the magnetic tape recorder. The weather data instrument panel consists of speed and direction indicators. Radio communication was maintained between the van, tow plane, and sailplane during all tests. Table II presents a list of instrumentation and calibration equipment used for this test.

The absolute sensitivity (NBS traceable) of the Bruel & Kjaer Sound Level Calibrator, type 4230, was determined before and after the test by means of a B&K type 4220 piston phone. The Sound Level Calibrator generates a sound pressure level (SPL) of 86 dB at 1000 Hz. The acoustic output of the calibrator was applied to each microphone and the system gain was adjusted such that a 1 volt full scale reading corresponded to an overall SPL from 46 to 96 dB.

Test Procedures

Each sailplane was towed to an altitude of 1500 to 2000 feet and released. After the tow plane had landed and shut down its engine and it was determined that there were no aircraft in the immediate vicinity, the sailplane began its descent to pass over the microphone array (Figure 8). The flight path of the sailplane was always such that it first passed over microphone 9, then microphone 1, and finally microphone 8. The tape recorder was turned on when the sailplanes were 1500 to 2000 feet away and were turned off approximately 20 seconds after the sailplanes had landed.

Flights were not scheduled unless the winds were predicted to be less than 5 knots. The tests were always conducted during the late afternoon, and early evening hours between approximately 4 and 8 o'clock. Gusty wind conditions sometimes prevailed until about 6 o'clock when the winds diminished. The wind speed and direction was continually recorded on tape and in addition was also verbally noted on tape as the sailplane passed over the microphone array.

The pilots attempted to maintain a constant velocity and configuration between microphones 9 and 8 during each flyby. The altitude and speed were determined by the pilot from the flight instrumentation as the sailplane passed over microphone 1. It was apparent during the first flybys, on 27 August, that the altitude determined by the pilot was in error. Consequently, during all further flybys, an observer with a transit set at a predetermined angle estimated the sailplane altitude as it passed over microphone 1. From a preliminary evaluation of the data obtained on 28 August, on the Schweizer 2-33, it appeared that, using the observer's estimated sailplane altitude, the data fit the expected velocity variation. However, preliminary evaluation of data from the Schweizer 2-32 and Libelle, taken on 10 September, indicated a need for better definition of the sailplane altitude and speed. Theodolite measurements were obtained during all remaining sailplane flybys conducted on 22 and 25 September. These measurements allowed determination of sailplane velocity and altitude within 1%. However, the determination of the distance the sailplane was off the flight path could be in error by as much as 15%.

Flights were conducted with a passenger in the Schweizer 2-32 to determine if varying gross weight affected the radiated noise. The Schweizer 2-32 was also flown over the microphones with the wing tip skids removed and tie down holes taped over in an attempt to remove possible noise sources.

In addition to measuring the flyby noise, two flights were conducted to determine at what altitude observers could detect the Schweizer 2-33 and the Libelle sailplanes. For these tests, each sailplane was towed to approximately 6000 feet altitude and then passed back and forth over the observers until the sailplane was heard. The altitude at which the sailplane was heard was determined through radio communications with the pilot.

Ambient noise measurements were obtained on 25 August and also as a minimum at the beginning and end of each day. Ambient records were also made at the end of each flyby after the sailplanes had landed, however in general these were not analyzed.

Data Reduction Procedures

Magnetic tapes recorded at the test site were played back in the Laboratory on a Honeywell 7400 tape record/reproduce system. Overall, octave, and one-third octave band analyses of the data were performed over the frequency range of 12.5 to 40,000 Hz using a B&K Model P-297 Rapid 1/3 - 1/1 Octave Band Analyzer. This system has a 60 dB dynamic range with ± 0.5 dB accuracy.

The flyby noise from the sailplanes is transient in that the magnitude of the noise increases as the sailplane approaches the microphone, reaches a maximum value, and then decreases after the sailplane passes over. Attempts were made in the analyses to obtain the spectra corresponding to the maximum noise. This was accomplished by operating the analyzer in its continuous mode and inserting a manual hold at that time judged to correspond to the maximum noise. The spectrum corresponding to this time was then plotted using the minimum time constant (0.3 seconds). The judgment of the occurrence of the time of the maximum was checked by setting the analyzer in the overall band and obtaining an overall analyses of the record of the flyby. The maximum values obtained in this manner were always found to be within 1 dB of the values corresponding to the plotted spectra.

Except for the measurements made on 25 August, ambient noise spectra were also obtained using the B&K Rapid 1/3 - 1/1 Octave Band Analyzer with a 0.3 second time constant. The ambient measurements made on 25 August were analyzed with the same analyzer but with a 10 second time constant. A narrow (10 Hz) bandwidth analysis of a selected point was obtained from the 25 August ambient measurement.

The narrow bandwidth analysis was performed using a Honeywell Model 9300 Power Spectral Density Analyzer. The analyzer is capable of computing and plotting various types of amplitude frequency functions of which the following is used in this report:

$$\text{rms Amplitude - vs - Frequency } (\sqrt{V^2})$$

The system linearity is ±0.5 dB for a discrete frequency input, however, with random processes there are additional statistical limits placed on the measurements. For this analysis 50 degrees of freedom were used which result in a standard error of approximately 20% with a confidence level of 67%. Narrow band analyses were also obtained using a Hewlett-Packard 5450 Fourier Analyzer.

Test Results

Each of the records obtained during the tests is listed in Table III with pertinent descriptive information including the date, tape number, record number, and sailplane identification. When available, values are given which correspond to the altitude, speed, and distance off the flight path determined by the pilot's instrumentation, ground observer's estimation with a transit, and results from two theodolite stations. The wind speed given in Table III is the observed value determined from the instrument panel in the van during the sailplane flyby. For the purposes of this report only data from microphone 1 have been analyzed. These data are presented and discussed in the following sections.

Ambient Noise

One-third octave band spectra from selected ambient noise recordings listed in Table III are given in Figures 11 through 21. These results are summarized in Figure 22 where the maximum, minimum, and median one-third octave band spectra are presented. These data do not include the ambient measurements made on 25 August when no flyby measurements were made. They do include ambient records made at the beginning and end of each day when flyby measurements were made. The ambient noise levels are generally low, however, considerable variation in one-third octave band levels occur throughout the spectrum.

A constant 10 Hz bandwidth analysis of the ambient record made on 25 August is presented in Figure 23. The relatively high levels in the 4000 to 5000 Hz range are a result of crickets. In the lower frequencies the spectrum results in a rather smooth curve, whereas in the intermediate and high frequencies the spectrum is peaked indicating the presence of discrete energy sources. Consequently, subtracting ten times the logarithm of the bandwidth from the one-third octave band level will not yield the spectrum level.

Schweizer 2-32 Sailplane

The records listed in Table III corresponding to the flybys of the Schweizer 2-32 are repeated in Table IV along with the best available determination of the sailplane altitude, speed, and distance off the flight path. In addition Table IV includes the corresponding overall sound pressure level obtained from the analysis and the sum of this level and 20 times the logarithm of the altitude, R. The one-third octave band spectra and overall SPL corresponding to each of these records are presented in Figures 24 through 46.

These data are summarized in Figure 47 where 10 log V is plotted against the sum of the overall SPL and 20 log R. Nearly all of these data are bounded by two straight lines each with a slope of six (6) (i.e. a sixth (6) power variation with velocity is assumed). The maximum overall SPL from all the Schweizer 2-32 flybys can be determined within ±7 dB from the solid line given in Figure 47. This line can be expressed as:

$$SPL_{OA} = 60 \log V - 20 \log R + 10 \log K_1 \quad (1)$$

where SPL_{OA} = Overall Sound Pressure Level - dB

V = Sailplane Velocity - ft/sec

R = Sailplane Altitude - ft

$10 \log K_1 = -21.2$

It was expected that an increase in gross weight would increase the radiated noise. However, those data points in Figure 47 corresponding to gross weight variation do not indicate a consistent trend. Those data points from flybys with a 135 pound passenger tend to be low whereas those data points from flybys with a 180 pound passenger tend to be high and the data point from the flyby with the 200 pound passenger is nearly on the best fit line.

Schweizer 2-33 Sailplane

The records listed in Table II corresponding to the flybys of the Schweizer 2-33 are repeated in Table V along with the best available determination of the sailplane altitude, speed, and distance off the flight path. In addition, Table V includes the corresponding overall SPL obtained from the analysis and the sum of this level and 20 times the logarithm of the altitude, R. The one-third octave band and overall SPL corresponding to each of these records are presented in Figures 48 through 60.

These data are summarized in Figure 61 where 10 log V is plotted against the sum of the overall SPL and 20 log R. Nearly all of these data are bounded by two straight lines each with a slope of six (6) (i.e. a sixth (6) power variation with velocity is assumed). The maximum overall SPL from all the Schweizer 2-33 flybys can be determined within ±7.5 dB from the solid line given in Figure 61. This line can be expressed as:

$$SPL_{OA} = 60 \log V - 20 \log R + 10 \log K_2 \qquad (2)$$

where $10 \log K_2 = -9.8$ and all other terms are defined above.

Libelle Sailplane

The records listed in Table III corresponding to the flybys of the Libelle are repeated in Table VI along with the best available determination of the sailplane altitude, speed, and distance off the flight path. In addition Table VI also includes the corresponding overall SPL obtained from the analysis and the sum of this level and 20 times the logarithm of the altitude, R. The one-third otave band and overall SPL corresponding to each of these records are presented in Figures 62 through 72.

These data are summarized in Figure 73 where 10 log V is plotted against the sum of the overall SPL and 20 log R. Nearly all of the data are bounded by two straight lines each with a slope of six (6) (i.e. a sixth (6) power variation with velocity is assumed). The maximum overall SPL from nearly all the Libelle flybys can be determined within ±4 dB from the solid line given in Figure 73. This line can be expressed as:

$$SPL_{OA} = 60 \log V - 20 \log R + 10 \log K_3 \qquad (3)$$

where $10 \log K_3 = -26.6$ and all other terms are defined above.

Radiated Noise from Three Sailplanes

As indicated in a previous section the most accurate determination of the sailplane altitude and speed was obtained from the theodolite measurements. Consequently, the desired relation between the overall SPL, velocity, and altitude should be obtained using those flybys where the theodolites were used. These data are presented in Figure 74 where 10 log V is plotted against the sum of the overall SPL and 20 log R.

This Figure includes data points from all sailplanes. However, those measurements where it was determined that the overall SPL was primarily controlled by a noise source other than the sailplane, were not included. The best fit line determined for each sailplane is identified in Figure 74. For a given velocity and altitude the overall SPL obtained from the lines given in Figure 74 show the noise from the Schweizer 2-33 to be 5.5 dB greater than the noise from the Schweizer 2-32 and 15 dB greater than the noise from the Libelle.

Doaks (Reference 2) in describing the noise radiated from foreign bodies in a turbulent fluid showed that this noise would increase directly with the turbulent area associated with the body. Consequently, if it is assumed that the noise measured from the sailplanes is generated by the mechanism described by Doaks then the expression for all the sailplanes would be:

$$SPL_{OA} + 20 \log R - 10 \log A = 60 \log V + 10 \log K \qquad (4)$$

where A is the turbulent area in ft^2 associated with each sailplane and all other terms are as defined above.

If the data points are corrected for area, as indicated in equation 4, then all the sailplane data should collapse if the predominant noise source is a direct function of the turbulent area. The data corrected for turbulent area are presented in Figure 75. It was assumed that the turbulent area associated with the Schweizer 2-32 was equal to the total wing area. Since the Schweizer 2-32 and Libelle both have laminar flow airfoil sections, it was assumed that their turbulent area would be one half their corresponding total wing area. The wing area of each of the sailplanes is included in Table I. All of these data are bounded by two straight lines each with a slope of six. The maximum overall SPL from all the sailplanes can be determined within ± 6 dB from the solid line given in Figure 75. This line is described by:

$$SPL_{OA} + 20 \log R - 10 \log A = 60 \log V - 42.7 \qquad (5)$$

Although the noise from the sailplanes only collapsed to within ± 6 dB, the data indicated that the noise increased with the turbulent area and the sixth power of velocity. The collapse obtained using the overall SPL is very encouraging since it is apparent from the sailplane noise spectra that the overall SPL was not always determined from the same frequency region indicating the presence of multiple sources of noise with complex directional characteristics. A better collapse of the data would result by considering those portions of the spectra corresponding to identified noise sources rather than the overall SPL. This approach is currently being pursued and the results will be presented in a forthcoming report. In addition, the spatial distribution of the radiated noise will be determined using the results from the total microphone array.

Aural Detection

The Schweizer 2-33 was aurally detected by four observers at approximately 2200 feet and 80° elevation while flying at a velocity of 50 mph (73.5 ft/sec). The Libelle was aurally detected by three observers at approximately 2600 feet and 80° elevation while flying at 60 knots (101 ft/sec). In each case the altitude and velocity were determined from the pilot's instrumentation.

Procedures for predicting the detection altitude for aircraft are given in Reference 3. These procedures require establishing a detection level curve generally determined by the background noise and the sensitivity of the ear. The altitude at which the aircraft can just be heard is then determined from the differences between the measured noise spectrum and the detection level curve taking into consideration spherical spreading and atmospheric absorption. In Reference 3 a different detection level curve is presented for pure tones and bands of noise. However, only the detection levels applicable to tones are applied in this report. Results indicate that when the spectrum level of the received noise is given, then the pure tone detection level curve should be used.

These procedures were followed and the resulting detection curve is presented in Figure 76 along with an estimated spectrum from the Schweizer 2-33 and Libelle sailplanes. The detection level curve was determined from the ambient noise measurements obtained on 25 August where a 10 second time constant was used in the analyses. The sensitivity of the ear did not enter into the evaluation and consequently is not included in the detection curve.

The spectra given for the Schweizer 2-33 were determined from records 52, 53, and 58 where altitude and velocity were determined by theodolites. Since the Schweizer 2-33 was flying at 50 mph when detected, it was necessary to correct the spectra from records 52, 53, and 58 to this velocity. The velocity correction was determined from Figure 74 which required subtracting 3 dB from the overall of run 52, 11 dB from the overall of run 53, and 16 dB from the overall of run 58.

In addition these spectra were also normalized to an altitude of 125 feet, using spherical spreading, by subtracting 42 dB from the corresponding value of the abscissa given in Figure 74. It was noted for the Schweizer 2-33 that the peak in the spectrum followed a Strouhal relationship (i.e., the peak frequency increased with velocity) consequently, this was accounted for in determining the average one-third octave band spectrum given in Figure 76.

In Reference 3 the detection altitude is determined by using the difference between the spectrum level of the received noise and the detection level. If the received noise is assumed to be white noise in a one-third octave band, then the spectrum level would be obtained from:

$$SPL_{SL} = SPL_{1/3} - 10 \log \Delta f, \text{ dB} \qquad (6)$$

where SPL_{ST} = Spectrum level - dB

$SPL_{1/3}$ = One-third octave SPL - dB

Δf = Bandwidth of the one-third octave band - Hz

With the assumption that the noise is white in a one-third octave band, the maximum difference between the spectrum level of the received noise from the Schweizer 2-33 and the detection level was determined to be 12 dB. From the curves given in Reference 3, the predicted altitude at which the Schweizer 2-33 would just be heard was determined to be 500 feet. A cursory look at the received spectrum from the Schweizer 2-33 flyby at 53 mph using a Hewlett-Packard 5450A Fourier Analyzer indicated that the received noise was not white. There were peaks in the spectra at 285 Hz and 310 Hz with the level of both being 37 dB. The difference between this spectrum level and the detection level at these frequencies results in a maximum of 21 dB. From the curves given in Reference 3, the predicted altitude at which the Schweizer 2-33 would just be heard was then determined to be 1300 feet.

The spectrum given in Figure 76 for the Libelle sailplane was determined from records 68 and 69 where the altitude and velocity were determined by theodolite. Since the Libelle was flying at 69 mph when detected, it was necessary to correct the spectra of records 68 and 69 to this velocity. The velocity correction was determined from Figure 74 which required subtracting 10 dB from the overall of record 68 and 11 dB from the overall of record 69. In addition these spectra were also normalized to an altitude of 125 feet, using spherical spreading, by subtracting 42 dB from the corresponding values of the abscissa given in Figure 74. It was noted for the Libelle that the peak in the spectrum follows a Strouhal relationship, as did the Schweizer 2-33, consequently this was accounted for in determining the average one-third octave band spectrum given in Figure 76. However, it was also noted that at the lower velocity flybys there was a substantial increase in the level of the one-third octave band centered at 1000 Hz indicating a resonant phenomena is generating the noise. From record 13, which was a flyby at 71 mph, the one-third octave band level at 1000 Hz was 54 dB. Correcting this level for altitude and velocity as above, results in a one-third octave band level of 51 dB at 1000 Hz. Consequently, a value of 51 dB is used at 1000 Hz in Figure 76.

As with the Schweizer 2-33, if it is assumed that the noise is white in a one-third octave band, the maximum difference between the spectrum level of the received noise from the Libelle and the detection level was 15.5 dB. Using the curves given in Reference 3, the predicted altitude at which the Libelle would be just heard was then determined to be 700 feet. However, using the Hewlett-Packard 5450A Fourier Analyzer, a peak was shown in the noise spectrum of record 13 at 1050 Hz with a spectrum level of 39 dB. The difference between this spectrum level and the detection level was 27 dB and the resulting altitude at which the Libelle would be just heard was determined to be 2100 feet.

It is apparent from these results that a detailed frequency analysis of the received noise is required in order to determine the aural detectability of an aircraft.

Appendix C

Tables and Figures

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Table I. Sailplane Specifications

Specifications	Sailplanes		
	Schweizer 2-32	Schweizer 2-33	Libelle
Wing Area - sq. ft.	180.0	219.5	102.3
Aspect Ratio	18.05	11.9	23.6
Wing Span - ft.	57.0	51.0	49.2
Mean Cord - ft.	3.15	4.3	2.08
Length - ft.	26.75	25.7	20.3
Height - ft.	9.0	9.4	4.3
Empty Weight - lbs.	850.0	600.0	397.0
Gross Weight - lbs.	1340.0	1040.0	552.0

Table II. List of Instrumentation

No.	Item	Manufacturer	Model No.
10	Microphone Cartridge	B&K	4132
10	Cathode Follower	B&K	2612
1	Piston Phone	B&K	4220
1	Tape Recorder	Honeywell	7400
10	Amplifier	Fairchild	ADO-24
1	Sound Level Calibrator	B&K	4230
1	Voltmeter	Hewlett-Packard	400D
10	Wind Screen	B&K	UA-0082
1	Oscilloscope	Tektronix	321A
1	Microphone	Shure	9898
10	Amplifier	Redcor	500
1	Amplifier	Hewlett-Packard	2460A
1	Time Code Generator	Astrodata	6100
1	Weather Forecaster	Multitech	Mark II

Table III. Records Obtained During Test

DATE	TAPE NO	REC NO	A/C	PILOT		OBSERVERS		THEODOLITE			WIND VEL (MPH)	COMMENTS
				ALT	V	ALT	D	ALT	V	D		
25/8	1	1	Ambient	-	-	-	-	-	-	-	-	
27/8	2	2	Ambient	-	-	-	-	-	-	-	3	
27/8	2	3	2-33	115	53	-	-	-	-	-	3-4	Slight Yaw passing over microphone
27/8	2	4	Libelle	115	93	-	-	-	-	-	2-3	Aircraft in vicinity during flyby
27/8	2	5	2-33	115	75	-	-	-	-	-	1-2	
27/8	2	6	Libelle	95	98	-	-	-	-	-	3	
27/8	2	8	2-33	115	88	-	-	-	-	-	3	
27/8	2	9	Ambient	-	-	-	-	-	-	-	3	
27/8	2	10	Libelle	55	69	-	-	-	-	-	3-4	
27/8	2	11	Libelle	95	46	-	-	-	-	-	0-4	Aircraft took-off in middle of flyby NG
27/8	2	12	Libelle	95	58	-	-	-	-	-	3	
27/8	3	13	Libelle	90	71	-	-	-	-	-	0	
27/8	3	14	Libelle*	-	-	-	-	-	-	-	0	Detected by 3 observers at approx. 2600 ft. and 80°

ALT = Altitude above microphone (feet)
V = Sailplane velocity (mph)
D = Distance left (-) or right (+) of flight path (feet)

Table III. Records Obtained During Test (Cont'd)

DATE	TAPE NO	REC NO	A/C	PILOT ALT	PILOT V	OBSERVERS ALT	OBSERVERS D	THEODOLITE ALT	THEODOLITE V	THEODOLITE D	WIND VEL (MPH)	COMMENTS
28/8	3	16	Ambient	-	-	-	-	-	-	-	0-	
28/8	3	17	2-33	125	50	105	-	-	-	-	2-3	
28/8	3	18	2-33	105	68	95	-	-	-	-	2-3	Applied air brakes 200 ft. from microphone
28/8	3	19	2-33	45	88	30	-	-	-	-	2-3	
28/8	3	20	2-33	120	80	105	-	-	-	-	0	Applied air brakes immediately after passing over microphone
28/8	3	21	2-33	120	90	110	-	-	-	-	0	Aircraft in vicinity during flyby
28/8	3	22	2-33	105	60	105	-	-	-	-	0	
28/8	3	23	2-33	*	50	-	-	-	-	-	0	Detected by observers at approx. 2200 ft. and 80 - 85°
28/8	3	24	Ambient	-	-	-	-	-	-	-	0	
28/8	3	25	2-33	120	60	120	-	-	-	-	0	
10/9	4	26	Ambient	-	-	-	-	-	-	-	0-1	
10/9	4	27	Ambient	-	-	-	-	-	-	-	2	

ALT = Altitude above microphone (feet
V = Sailplane velocity (mph)
D = Distance left (-) or right (+) of flight path (feet)

Table III. Records Obtained During Test (Cont'd)

DATE	TAPE NO	REC NO	A/C	PILOT ALT	PILOT V	OBSERVERS ALT	OBSERVERS D	THEODOLITE ALT	THEODOLITE V	THEODOLITE D	WIND VEL (MPH)	COMMENTS
10/9	4	28	2-32	145	60	85	-	-	-	-	2-3	
10/9	4	29	2-32	120	75	105	-	-	-	-	8-10	
10/9	4	30	2-32	120	75	120	-	-	-	-	3-4	May have applied air brakes between microphones
10/9	4	31	2-32	120	90	85	-	-	-	-	3-4	
10/9	4	32	2-32	-	100	95	-	-	-	-	2-3	Flap setting of 0°
10/9	4	33	Libelle	120	58	85	-	-	-	-	3-4	Tractor operating in vicinity during flyby
10/9	4	34	2-32	125	70	80	-	-	-	-	0-3	
10/9	4	35	2-32	120	80	130	-	-	-	-	0-2	
10/9	4	36	Ambient	-	-	-	-	-	-	-	2[illegible]	
10/9	4	37	Ambient	-	-	-	-	-	-	-	0-2	
10/9	4	38	2-32	120	90	110	-	-	-	-	0-2	
10/9	4	39	Libelle	115	97	85	-	-	-	-	0-2	Flap setting of -1°
10-9	4	40	Libelle	115	79	85	-	-	-	-	0	Flap setting of -1°

ALT = Altitude above microphone (feet)
V = Sailplane velocity (mph)
D = Distance left (-) or right (+) of flight path (feet)

Table III. Records Obtained During Test (Cont'd)

DATE	TAPE NO	REC NO	A/C	PILOT ALT	PILOT V	OBSERVERS ALT	OBSERVERS D	THEODOLITE ALT	THEODOLITE V	THEODOLITE D	WIND VEL (MPH)	COMMENTS
22/9	5	42	Ambient	-	-	-	-	-	-	-	5-6	
22/9	5	43	Ambient	-	-	-	-	-	-	-	5-6	
22/9	5	44	Abort	-	-	-	-	-	-	-	-	Tape not turned on
22/9	5	45	2-32	120	60	105	-	80	65	+19	2-3	
22/9	5	46	2-32	500	80	-	-	413	88	+7	2-3	
22/9	5	47	2-32	120	60	170	-	150	65	+12	8-9	
22/9	5	48	2-32	120	80	100	-	89	84	-6	5-6	
22/9	5	49	2-32	95	90	60	-7	32	75	-	5-6	
22/9	5	50	2-32	120	120	45	-25	47	125	-18	6-8	
22/9	5	51	2-32	-	70	80	0	66	82	-14	6-8	
22/9	5	52	2-33	145	55	145	-10	178	53	-2	0	
22/9	5	53	2-33	120	70	145	-10	148	75	-8	0-1	
22/9	5	54	2-32	120	60	110	0	88	70	-1	0-1	135 lb. passenger, aircraft in vicinity during flyby

ALT = Altitude above microphone (feet)
V = Sailplane velocity (mph)
D = Distance left (-) or right (+) of flight path (feet)

Table III. Records Obtained During Test (Cont'd)

DATE	TAPE NO	REC NO	A/C	PILOT		OBSERVERS		THEODOLITE			WIND VEL (MPH)	COMMENTS
				ALT	V	ALT	D	ALT	V	D		
22/9	5	55	2-32	120	60	140	-7	130	67	-7	0-1	135 lb passenger, aircraft in vicinity during flyby
22/9	5	56	2-32	120	80	115	0	111	91	+5	2-4	135 lb passenger
22/9	5	57	2-32	120	100	90	-5	87	110	-4	0-1	135 lb passenger
22/9	5	58	2-33	120	90	90	0	30	97	-10	1-2	
22/9	5	59	Ambient	-	-	-	-	-	-	-	0	
22/9	5	61	Ambient	-	-	-	-	-	-	-	0-1	
22/9	5	62	Ambient	-	-	-	-	-	-	-	3	
22/9	5	63	Ambient	-	-	-	-	-	-	-	3	
22/9	5	64	2-32	250	77	200	0	167	77	+2	0	
22/9	5	65	2-32	120	60	110	0	105	60	+7	3-4	180 lb passenger, clean configuration
22/9	5	66	2-32	95	80	45	-10	29	82	-6	2-3	180 lb passenger, clean configuration
22/9	5	67	2-32	95	95	50	-5	48	91	-5	2-3	180 lb passenger, clean configuration, aircraft in vicinity

ALT = Altitude above microphone (feet)
V = Sailplane velocity (mph)
D = Distance left (-) or right (+) of flight path (feet)

Table III. Records Obtained During Test (Cont'd)

DATE	TAPE NO	REC NO	A/C	PILOT		OBSERVERS		THEODOLITE			WIND VEL (MPH)	COMMENTS
				ALT	V	ALT	D	ALT	V	D		
22/9	5	68	Libelle	120	101	50	-5	60	96	-10	0	
22/9	5	69	Libelle	105	115	85	-5	86	108	-9	0	Yawed between microphones during flyby
22/9	5	70	Libelle	95	83	-	-5	72	81	-4	0	Aircraft in vicinity during flyby
22/9	5	71	2-32	120	100	-	0	81	100	-4	0	200 lb passenger

ALT = Altitude above microphone (feet)
V = Sailplane velocity (mph)
D = Distance left (-) or right (+) of flight path (feet)

Table IV. Overall Sound Pressure Level Measured During the Flyby of the Schweizer 2-32 Sailplane

Record Nr	Altitude (ft)	Velocity (Ft/Sec)	SPL_{OA} (dB)	10 log V	SPL_{OA} + 20 log $\bar{R}$ (dB)
28	85[a]	88[b]	69	19.44	102.6
30	120[a]	110[b]	64	20.42	105.6
31	85[a]	132[b]	73	21.20	111.6
32	95[a]	147[b]	73	21.68	112.6
34	80[a]	103[b]	64	20.13	102.1
35	130[a]	117[b]	62	20.68	108.2
38	110[a]	132[b]	66	21.20	101.4
45	80[c]	95[c]	56	19.78	94.1
46	413[c]	129[c]	63	21.10	115.3
47	150[c]	95[c]	61	19.78	104.5
48	89[c]	123[c]	61	20.90	100.0
49	32[c]	110[c]	73	20.42	103.1
50	47[c]	183[c]	75	22.63	108.4
51	66[c]	120[c]	63	20.80	100.4
54	88[c]	103[c]	60	20.13	98.9
55[d]	130[c]	98[c]	57	19.92	99.3
56[d]	111[c]	133[c]	59	21.24	99.8
57[d]	87[c]	161[c]	66	22.07	104.8
64	167[c]	113[c]	62	20.53	106.5
65[e]	105[c]	88[c]	60	19.44	100.4
66[e]	45[c]	120[c]	74	20.80	107.1
67[e]	48[c]	133[c]	74	21.24	107.6
71[f]	81[c]	147[c]	70	21.68	108.2

a = Ground Observer's Estimated Altitude
b = Velocity Determined from Pilot's Instrumentation
c = Altitude and Velocity Determined from Theodolites
d = 135# Passenger
e = 180# Passenger
f = 200# Passenger

Table V. Overall Sound Pressure Level Measured During the Flyby of the Schweizer 2-33 Sailplane

Record Nr	Altitude (Ft)	Velocity (Ft/Sec)	SPL_{OA} (dB)	10 log V	SPL_{OA} + 20 log R (dB)
3	115[a]	77.7[b]	77	18.91	118.2
5	115[a]	110.0[b]	79	20.42	120.2
8	115[a]	129.0[b]	79.5	21.11	120.7
17	105[c]	73.0[b]	61	18.63	101.4
18	95[c]	99.7[b]	70.5	19.99	110.1
19	30[c]	129.0[b]	87	21.11	116.5
20	105[c]	117.0[b]	70	20.68	110.4
21	110[c]	132.0[b]	75	21.21	115.8
22	105[c]	88.0[b]	65.5	19.45	105.9
25	120[c]	88.0[b]	62	19.45	103.6
52	178[d]	77.7[d]	54	20.42	199.9
53	148	110.0	63.5	21.54	106.1
58	80	142.0	74	18.91	112.0

a = Altitude Determined from Pilot's Estimate
b = Velocity Determined from Pilot's Estimate
c = Altitude Determined from Ground Observer's Estimate
d = Altitude and Velocity Determined from Theodolites

Table VI. Overall Sound Pressure Level Measured During the Flyby of the Libelle Sailplane

Record Nr	Altitude (Ft)	Velocity (Ft/Sec)	SPL_{OA} (dB)	10 log V	SPL_{OA} + 20 log R (dB)
4	115[a]	139[a]	65	21.44	106.2
6	95[a]	144[a]	65	21.57	104.6
10	55[a]	101[a]	67	20.05	101.8
12	95[a]	85[a]	72.5	19.30	112.1
13	90[a]	104[a]	58	20.17	97.1
33	85[b]	85[a]	63	19.30	101.6
39	85[b]	142[a]	62.5	21.53	101.1
40	85[b]	115[a]	58	20.64	96.6
68	60[c]	140[c]	63	21.48	98.6
69	86[c]	158[c]	62	22.00	100.7
70	72[c]	122[c]	62.5	20.85	99.7

a = Altitude and Velocity Determined from Pilot's Instrumentation
b = Altitude Determined by Ground Observer
c = Altitude and Velocity Determined from Theodolites

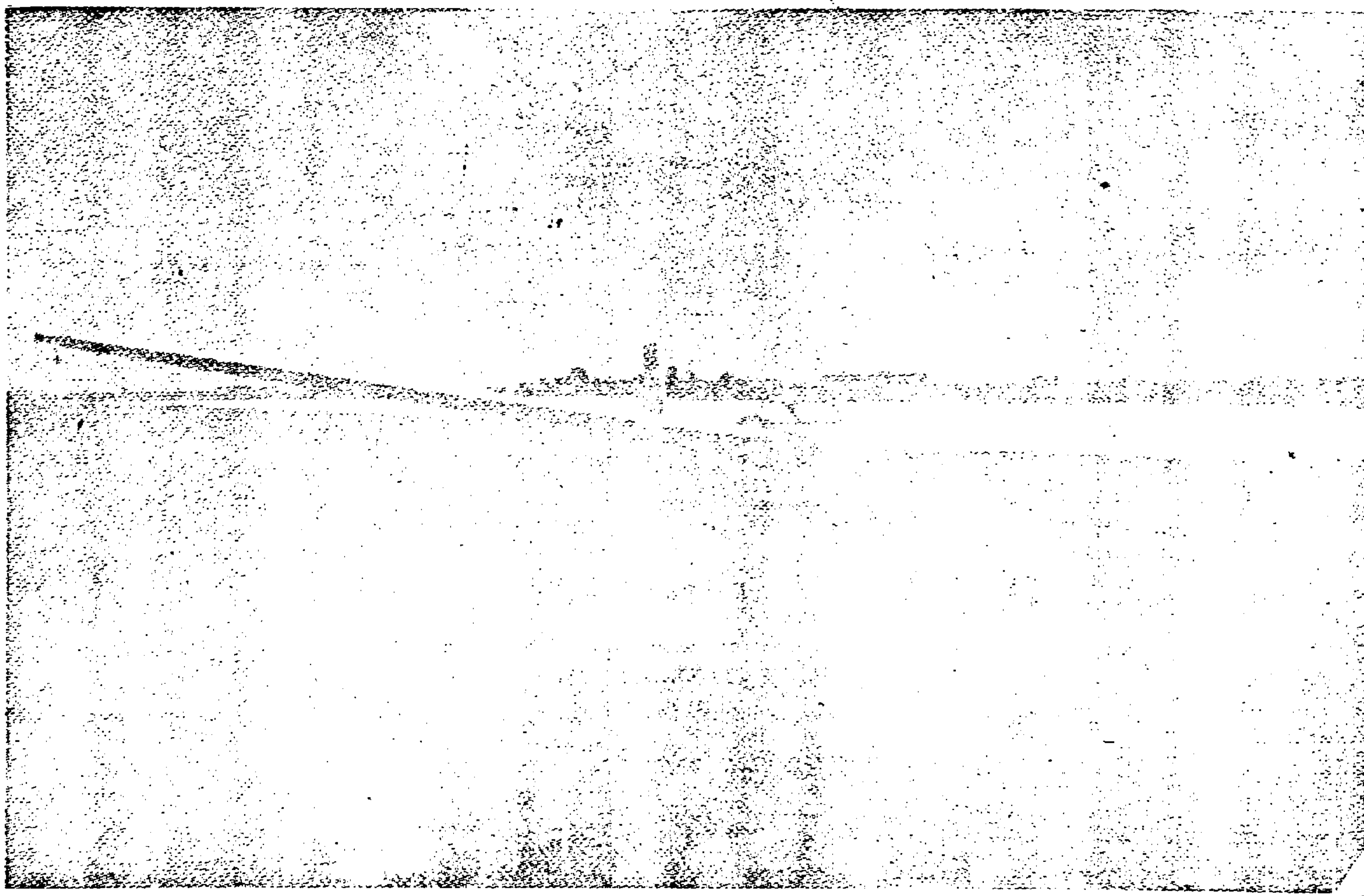

FIG 1. SCHWEIZER 2-32 SAILPLANE

AFLC-WPAFB-FEB 70 50

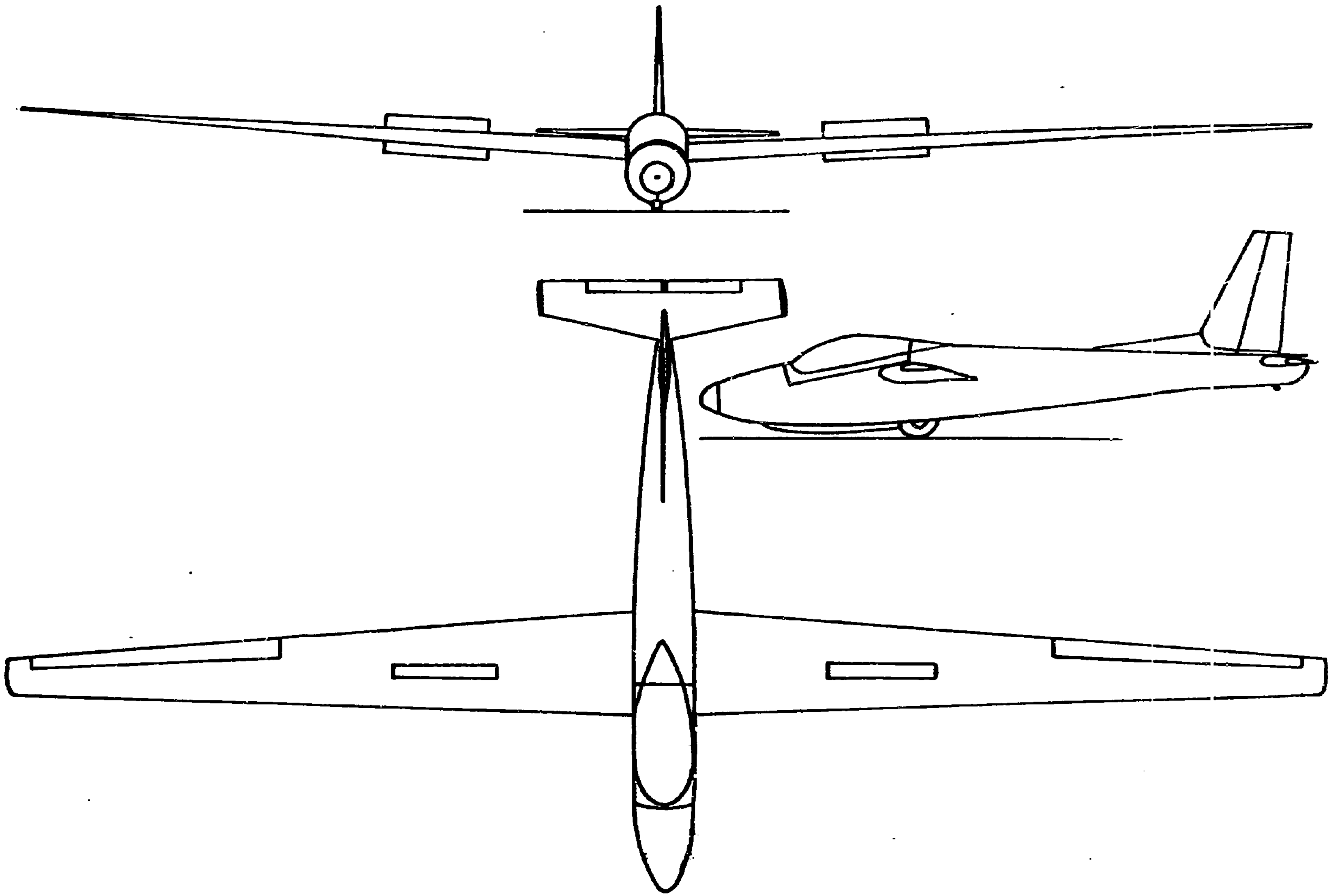

FIG 2. THREE VIEW LAYOUT OF SCHWEIZER 2-32 SAILPLANE

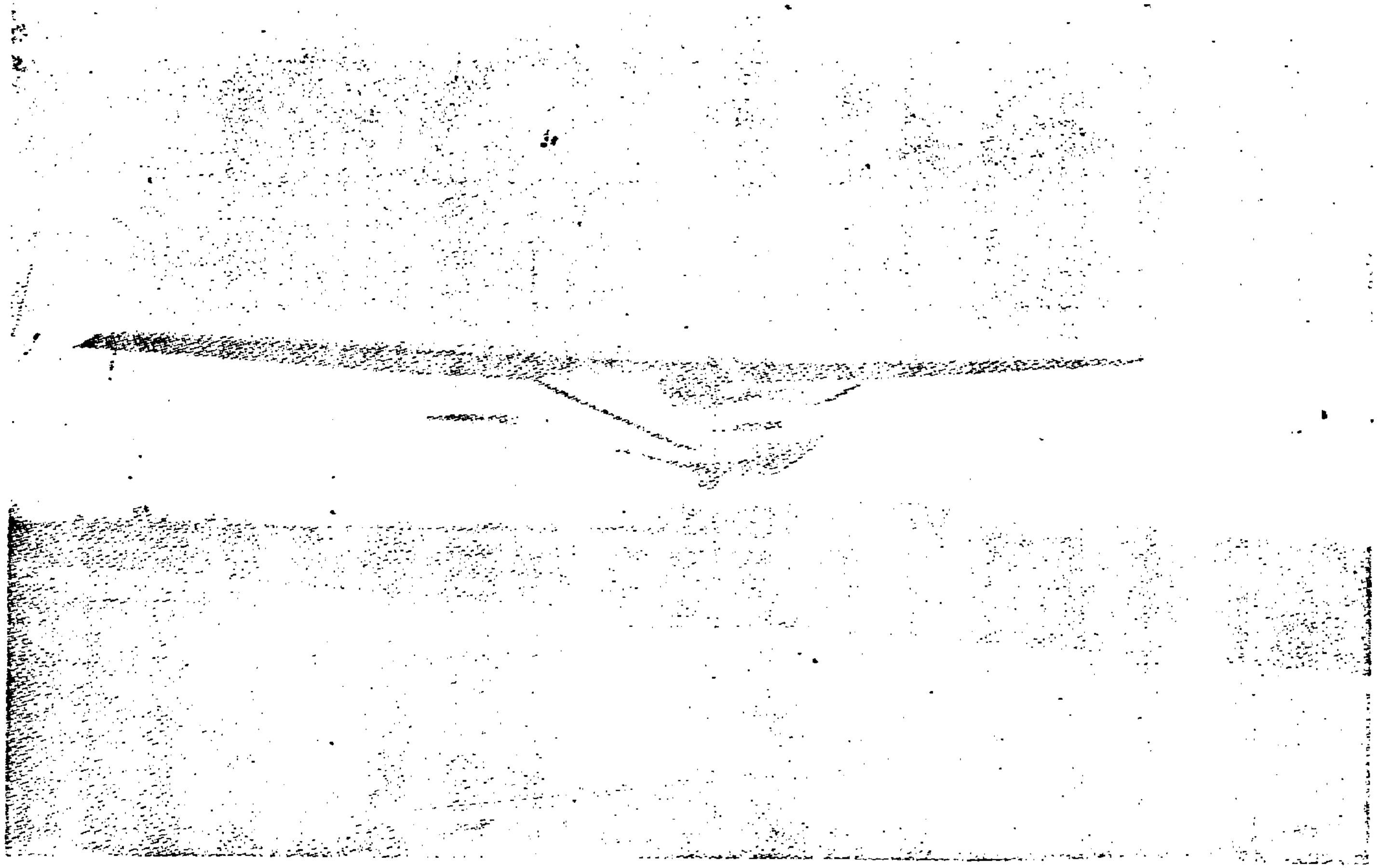

FIG 3. SCHWEIZER 2-33 SAILPLANE

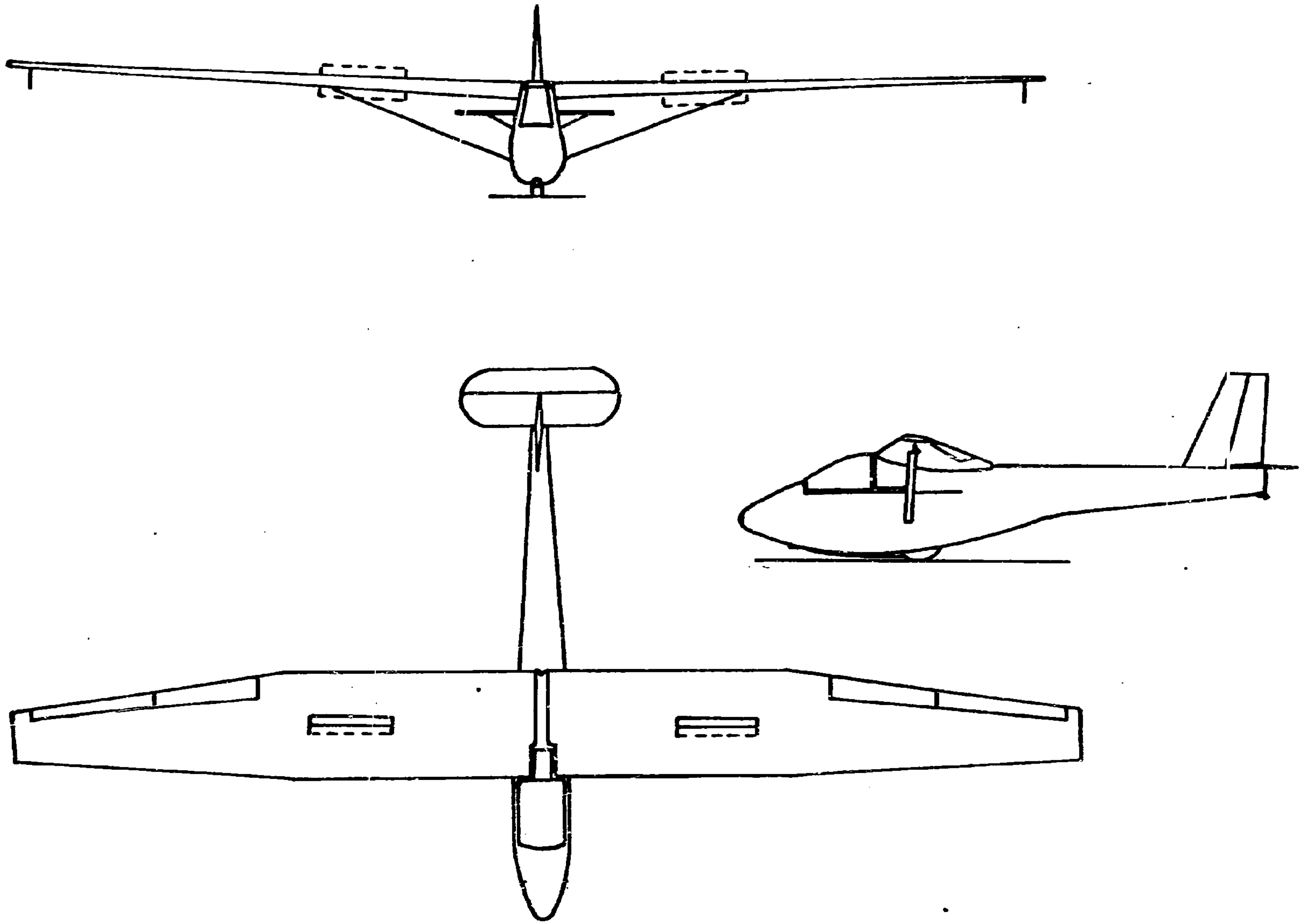

FIG 4. THREE VIEW LAYOUT OF SCHWEIZER 2-33 SAILPLANE

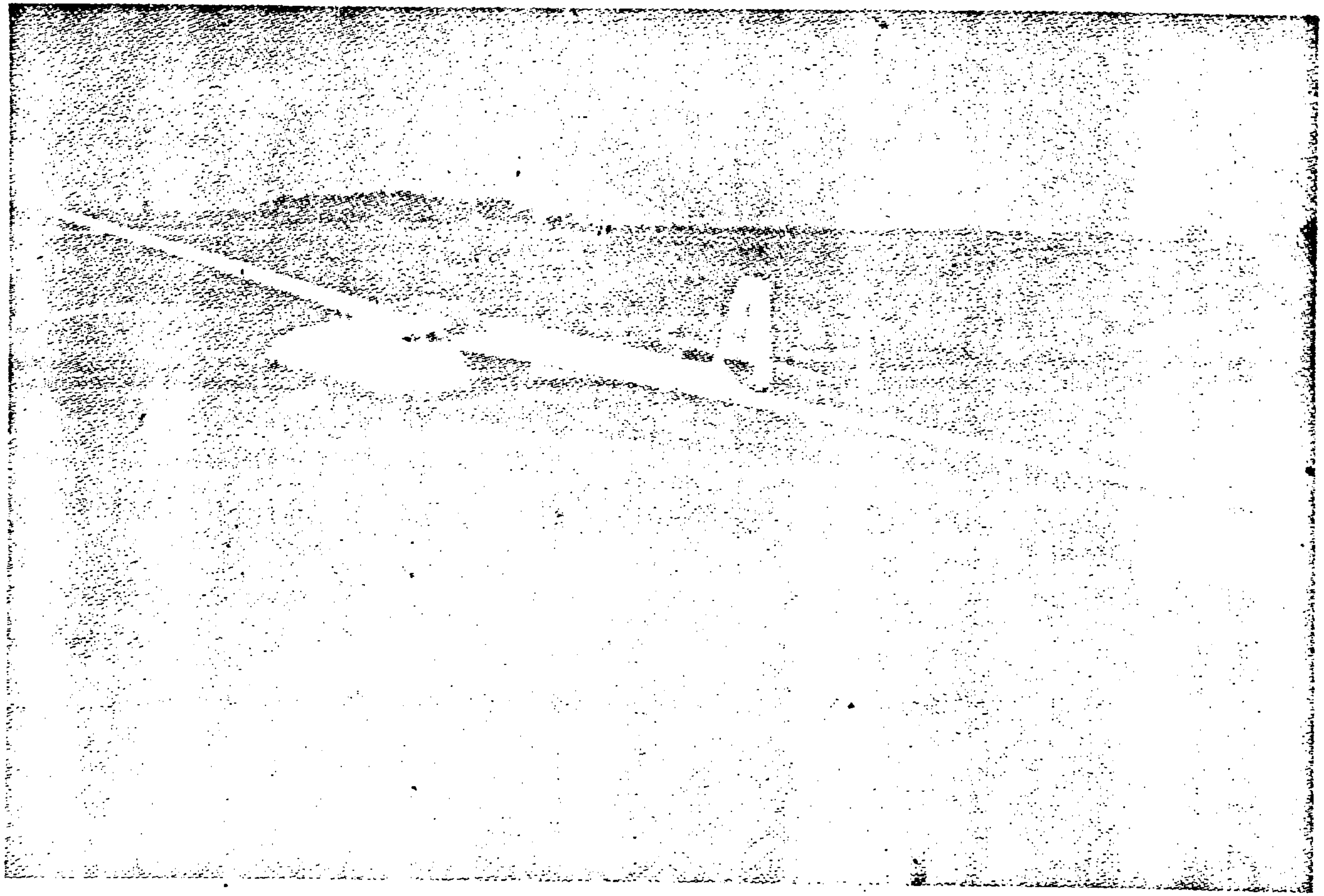

FIG 5. LIBELLE SAILPLANE

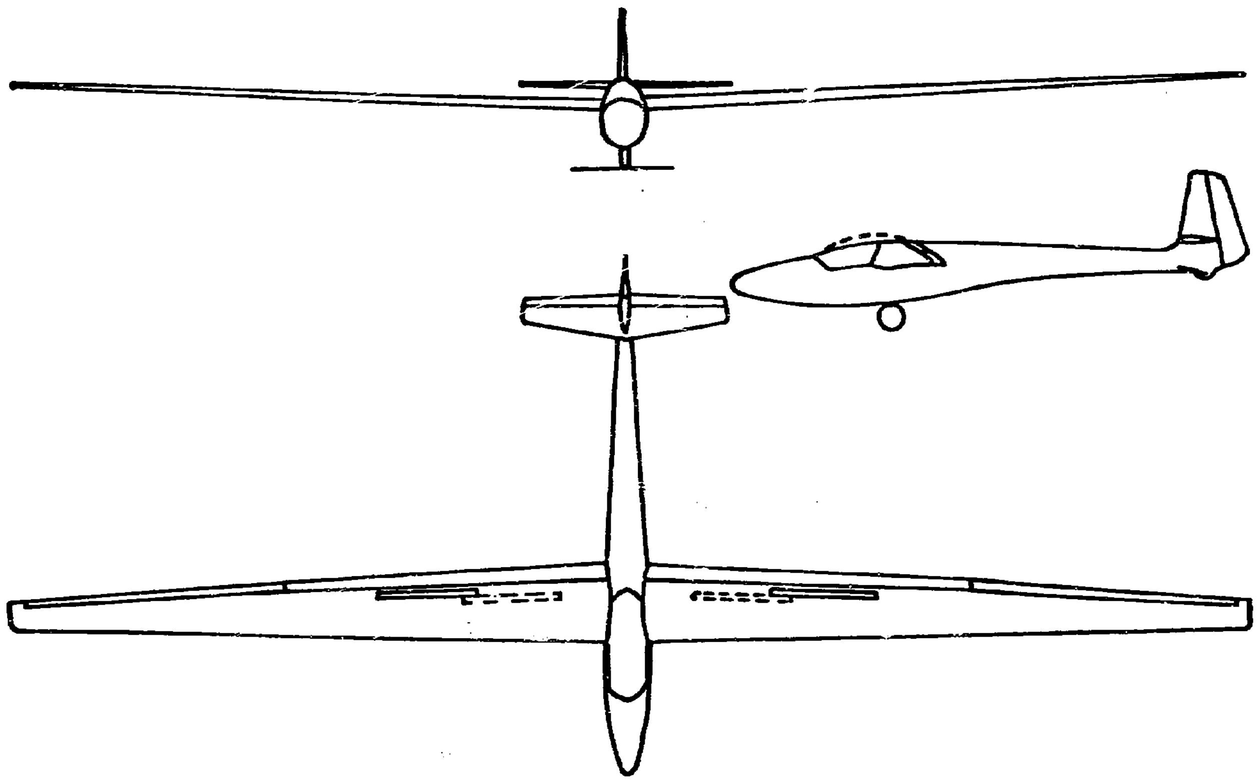

FIG 6. THREE VIEW LAYOUT OF LIBELLE SAILPLANE

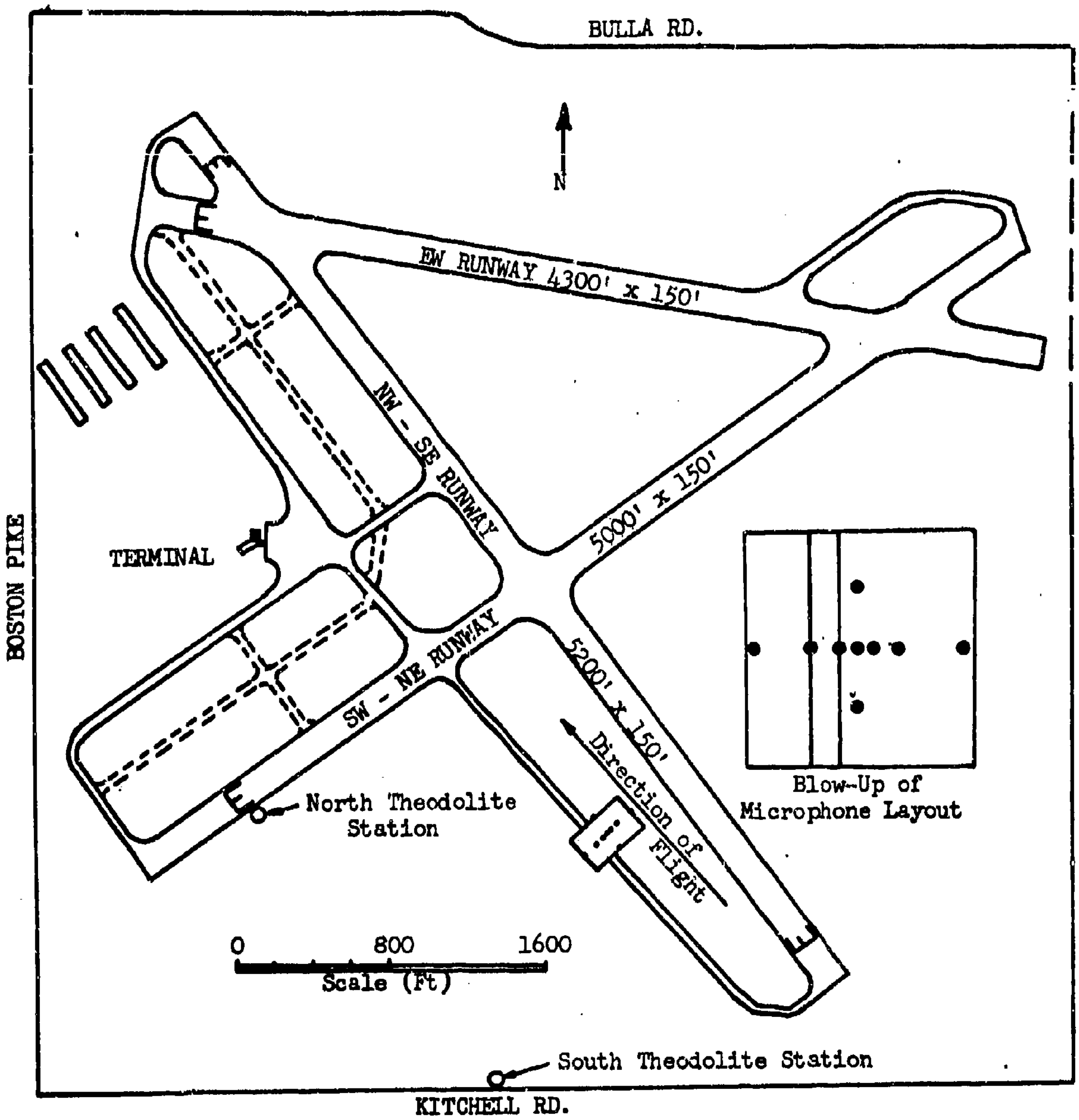

FIG 7. TEST SITE AT RICHMOND MUNICIPAL AIRPORT, BOSTON, INDIANA

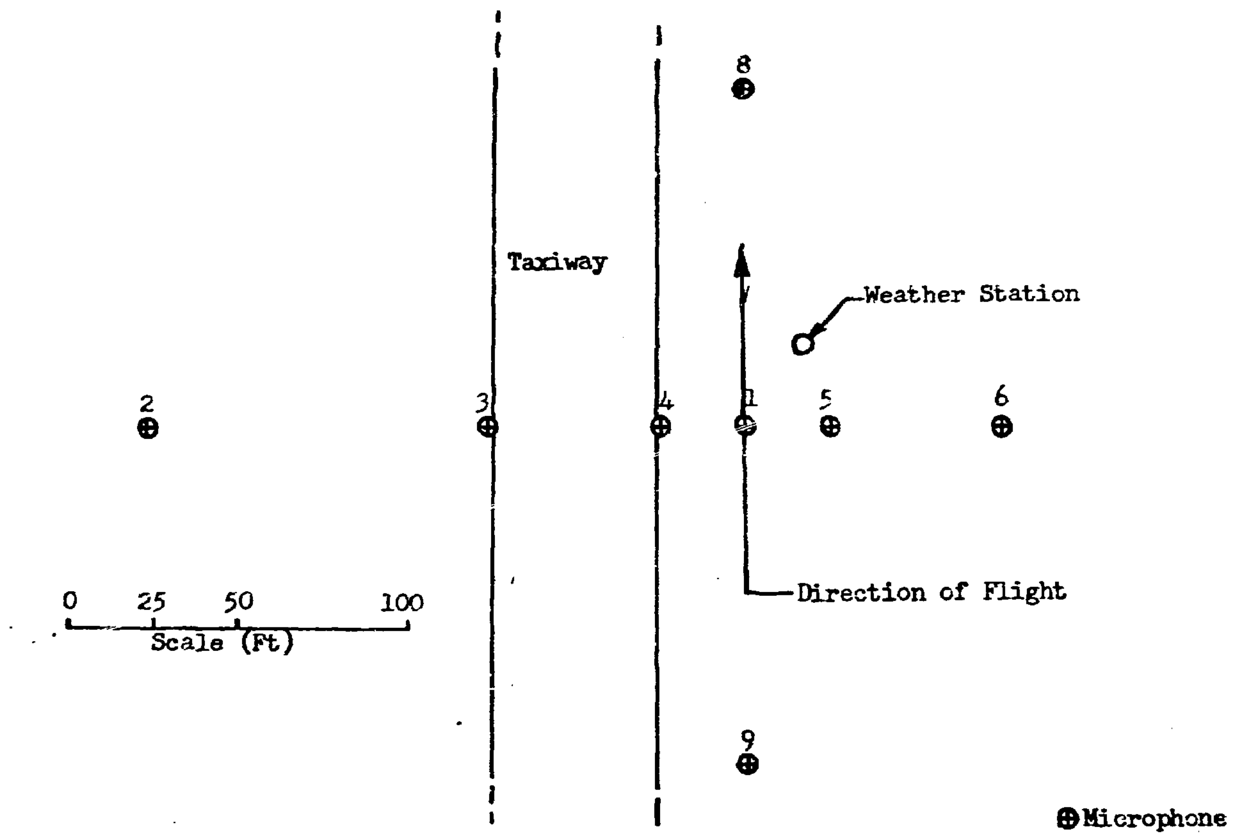

FIG 8. MICROPHONE LAYOUT

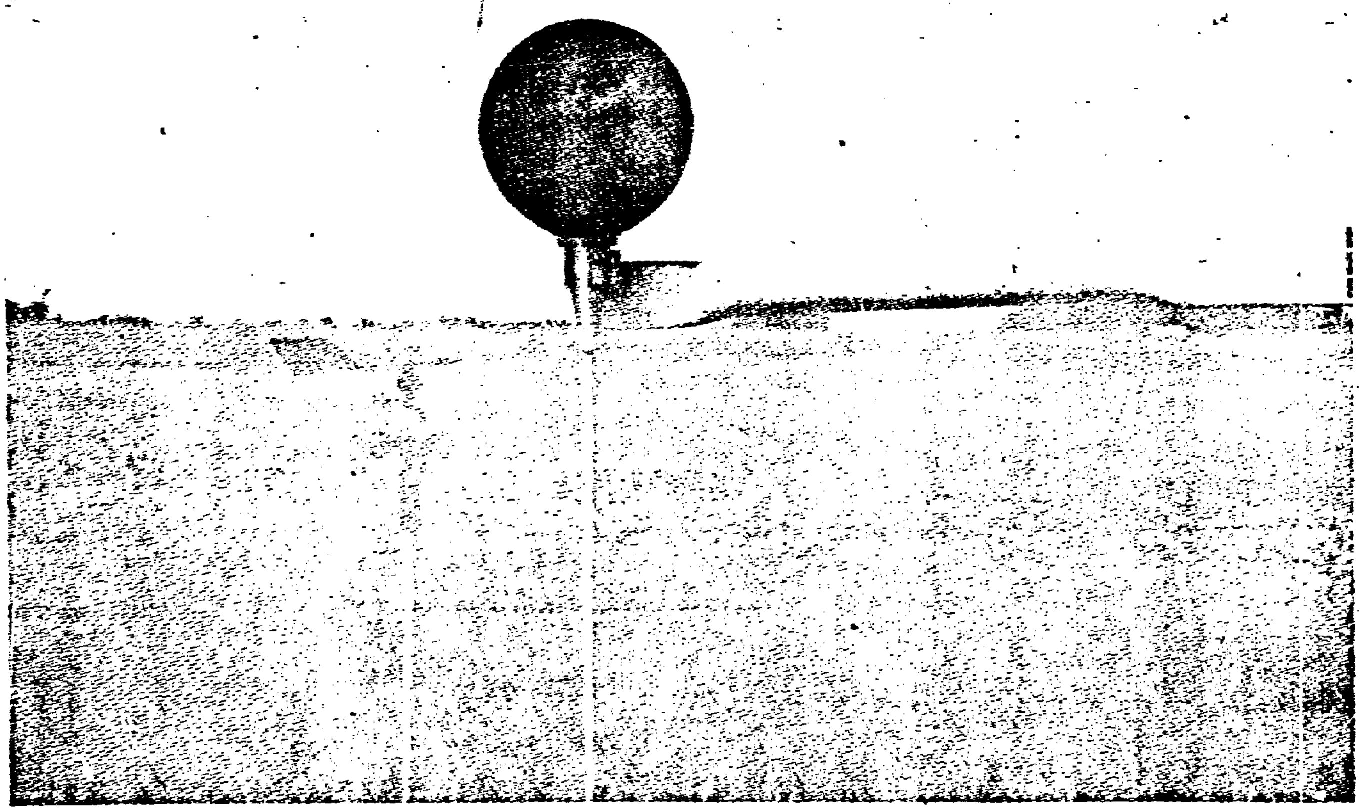

FIG 9. TYPICAL MICROPHONE INSTALLATION AND WEATHER STATION SET-UP

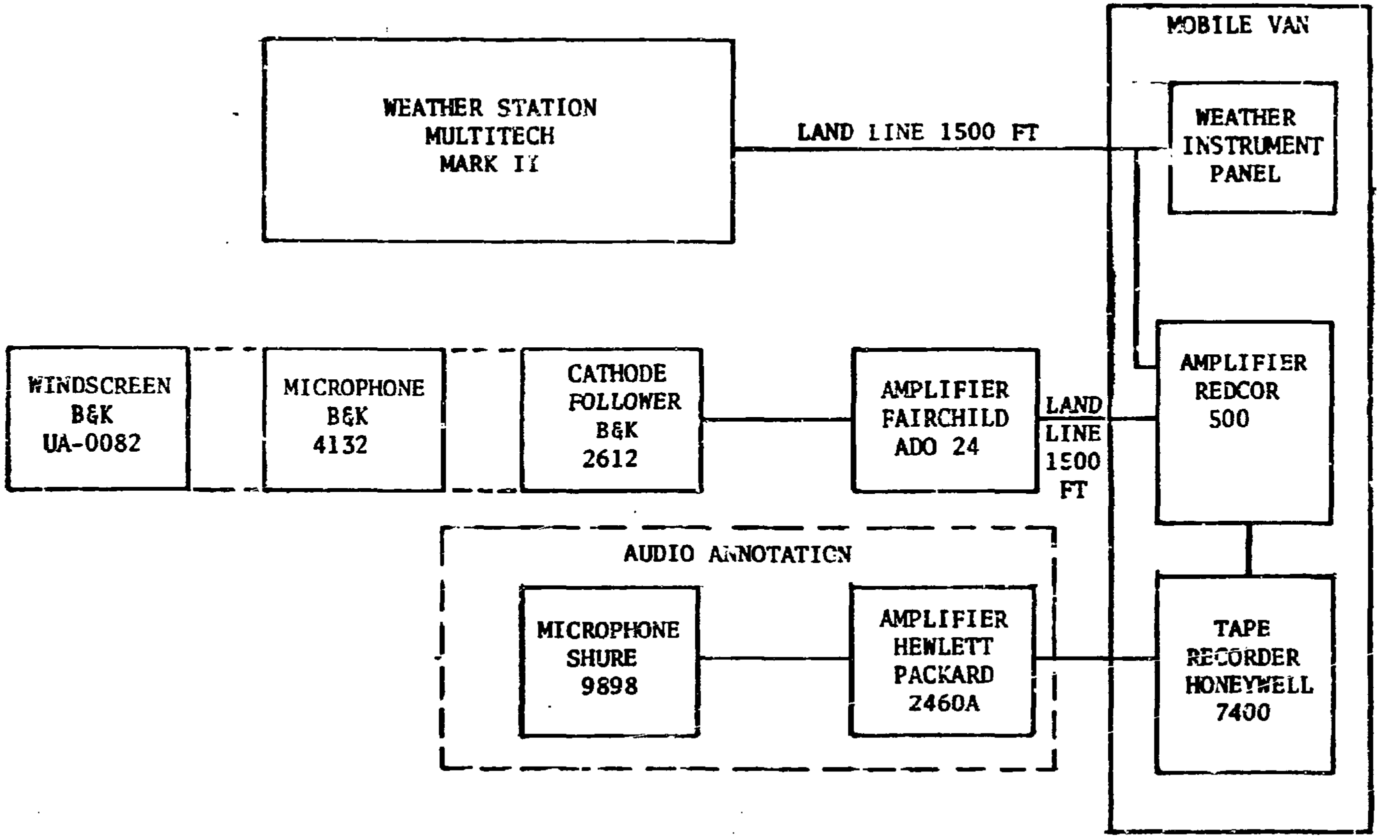

FIG 10. BLOCK DIAGRAM OF DATA ACQUISITION SYSTEM

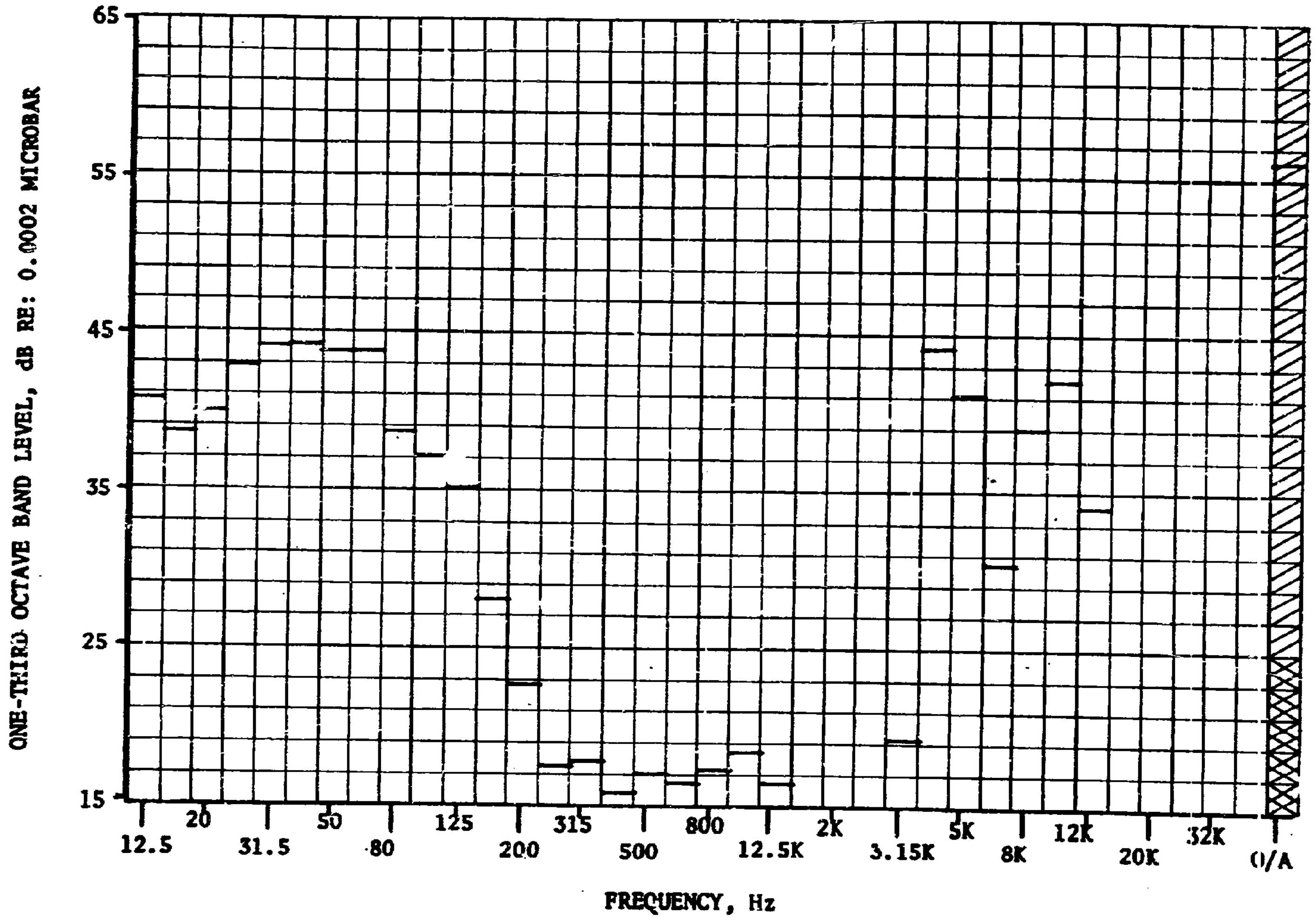

FIG 11. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 25 AUGUST 1969 (RECORD 1)

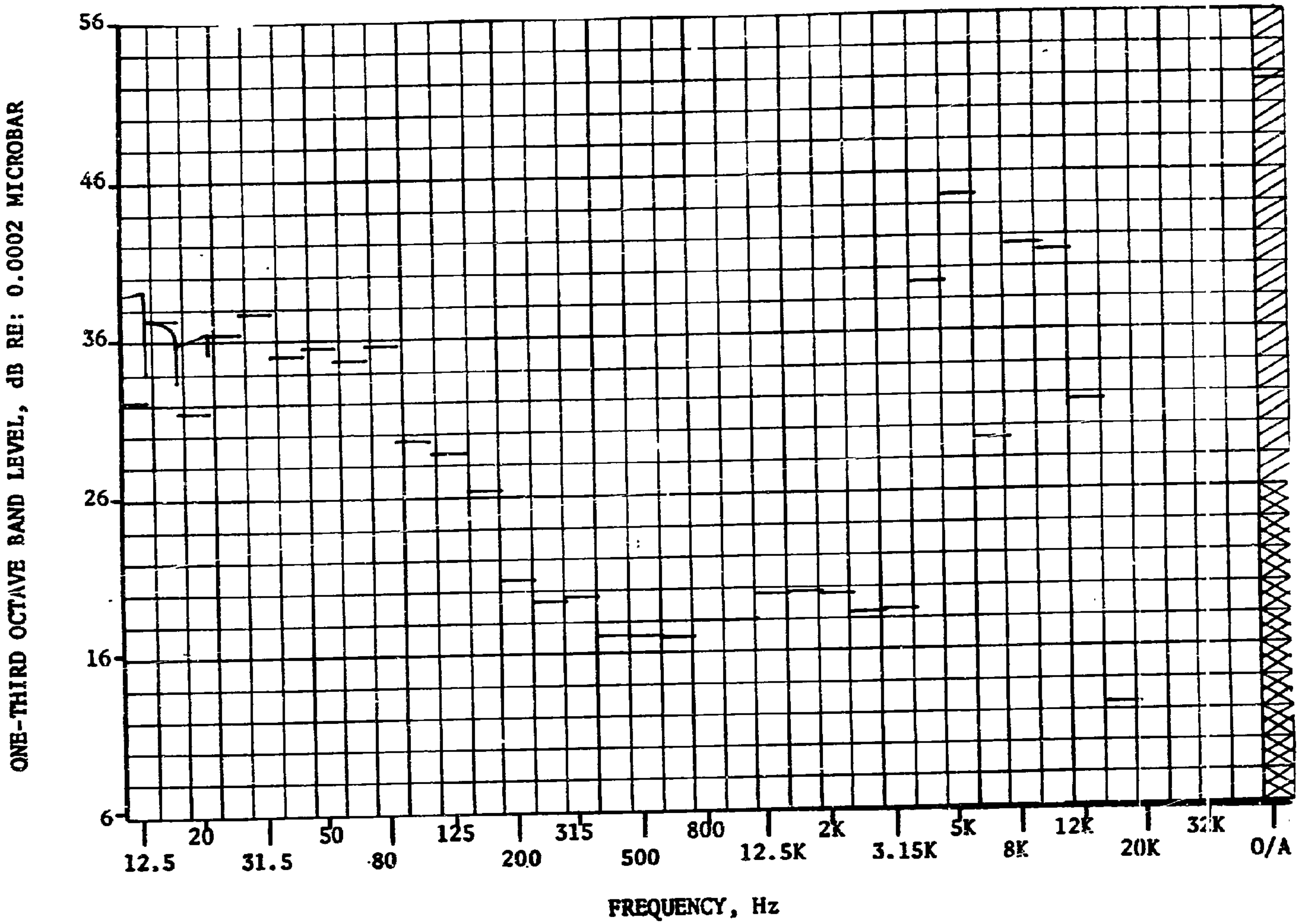

FIG 12. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 27 AUGUST 1969 (RECORD 2)

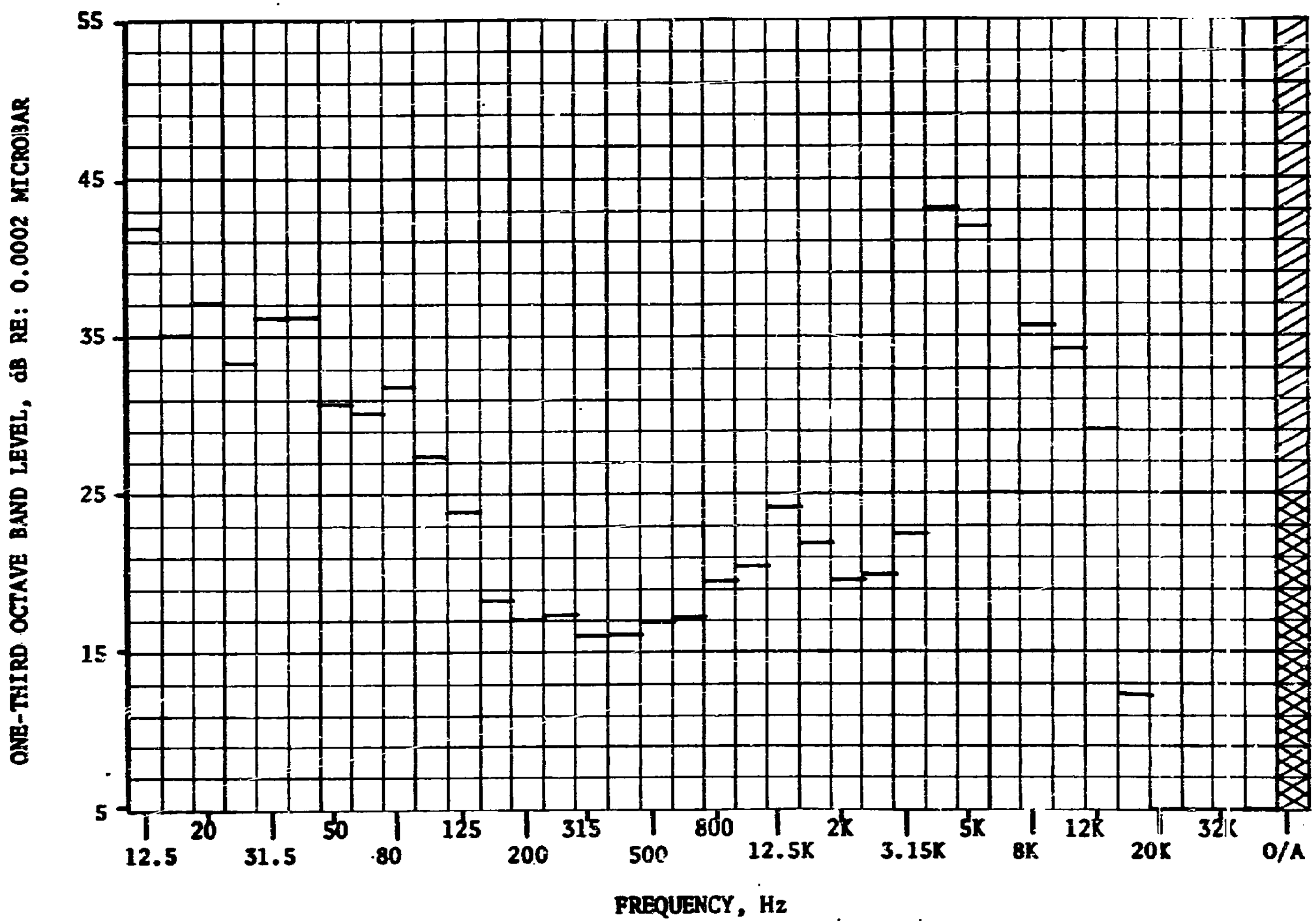

FIG 13. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 27 AUGUST 1969 (RECORD 9)

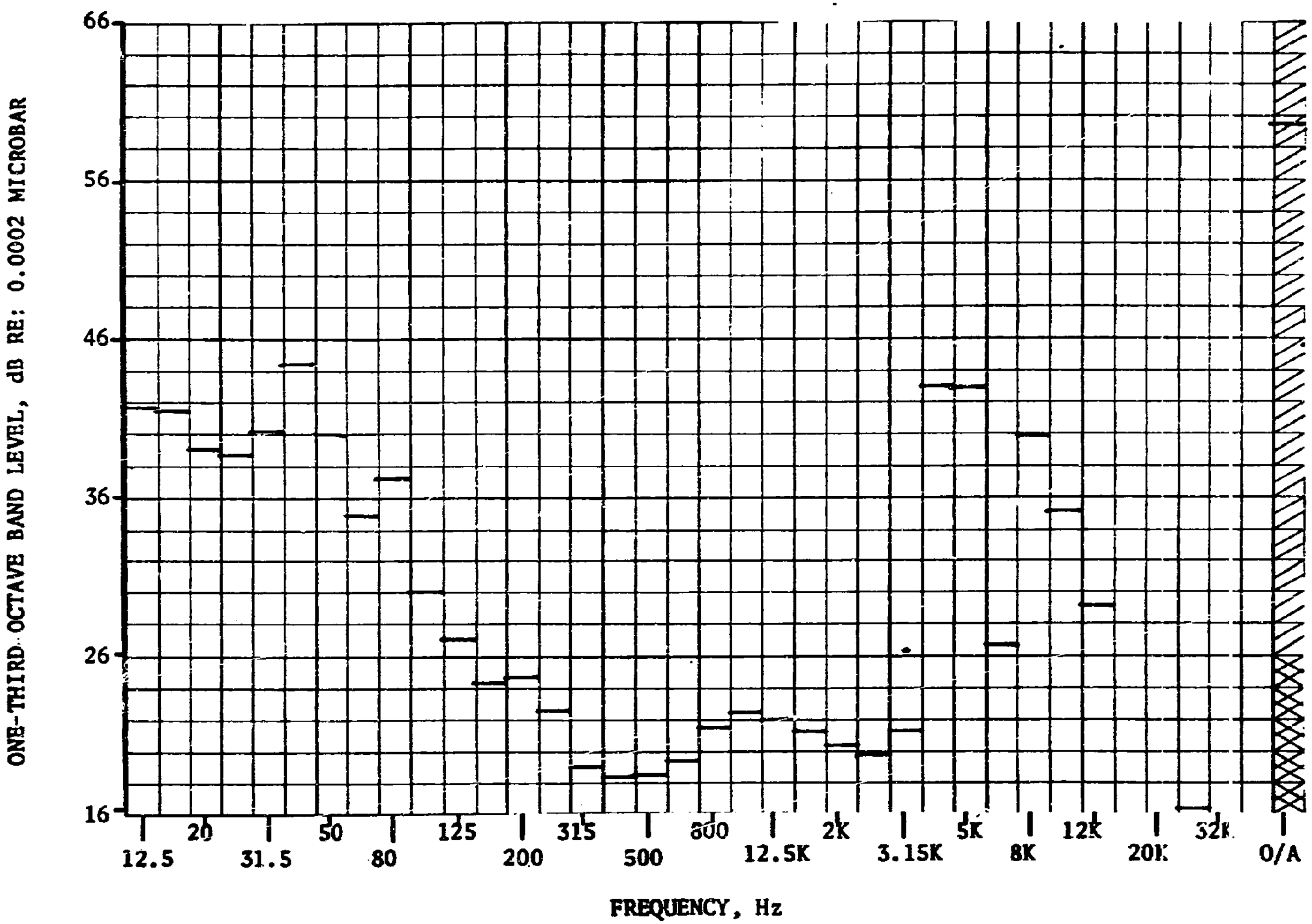

FIG 14. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 28 AUGUST 1969 (RECORD 16)

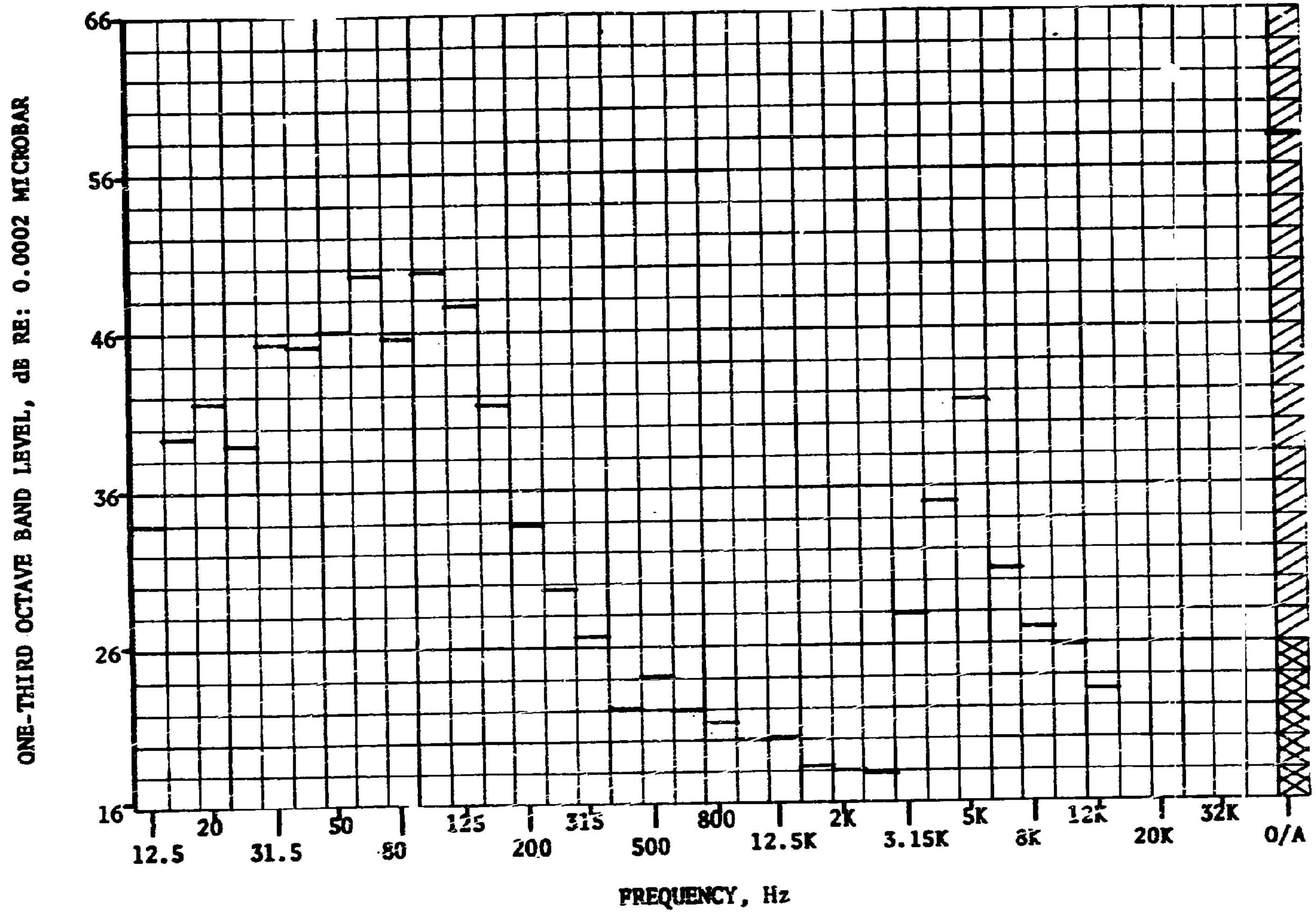

FIG 15. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 28 AUGUST 1969 (RECORD 25)

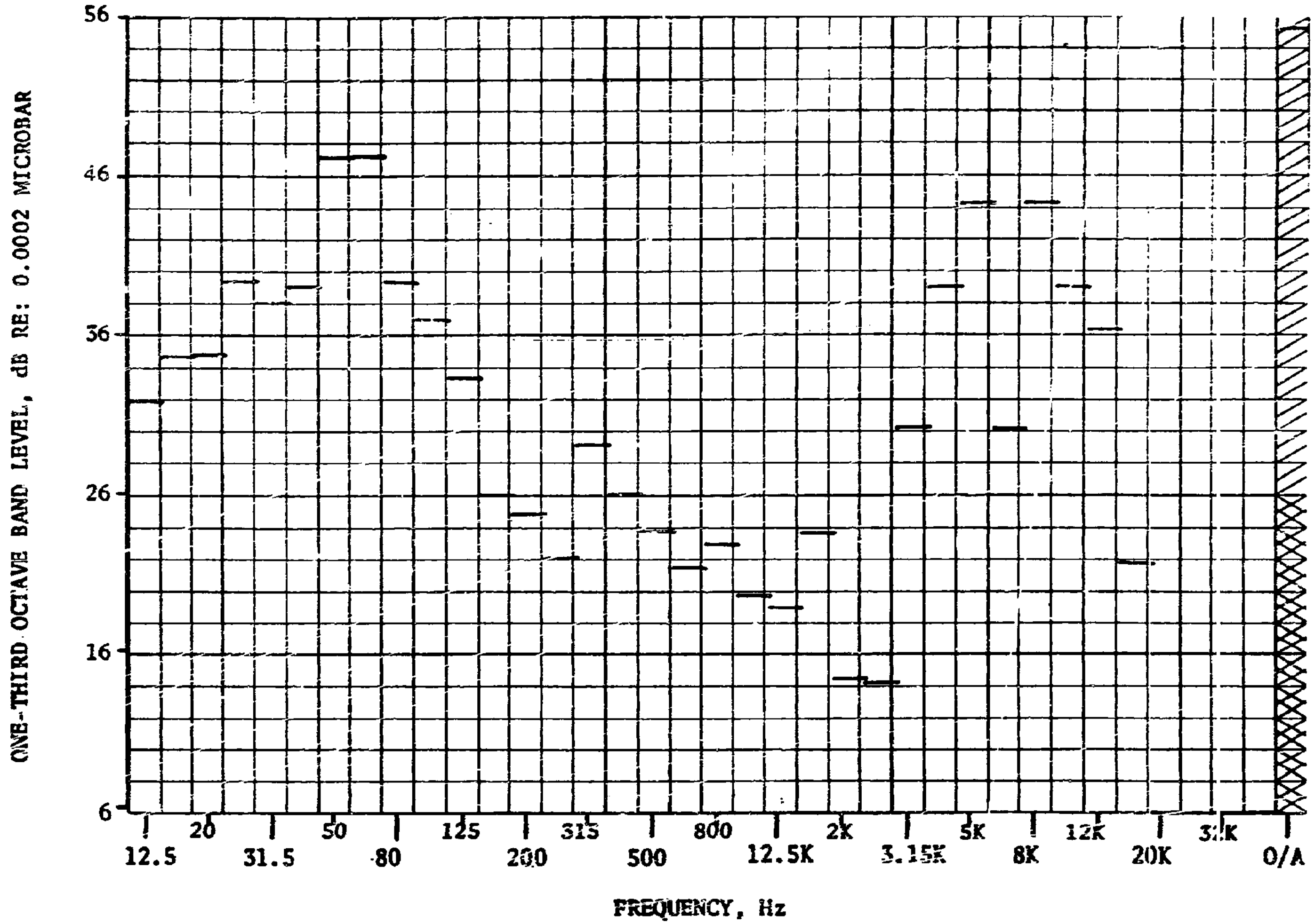

FIG 16. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 10 SEPTEMBER 1969 (RECORD 27)

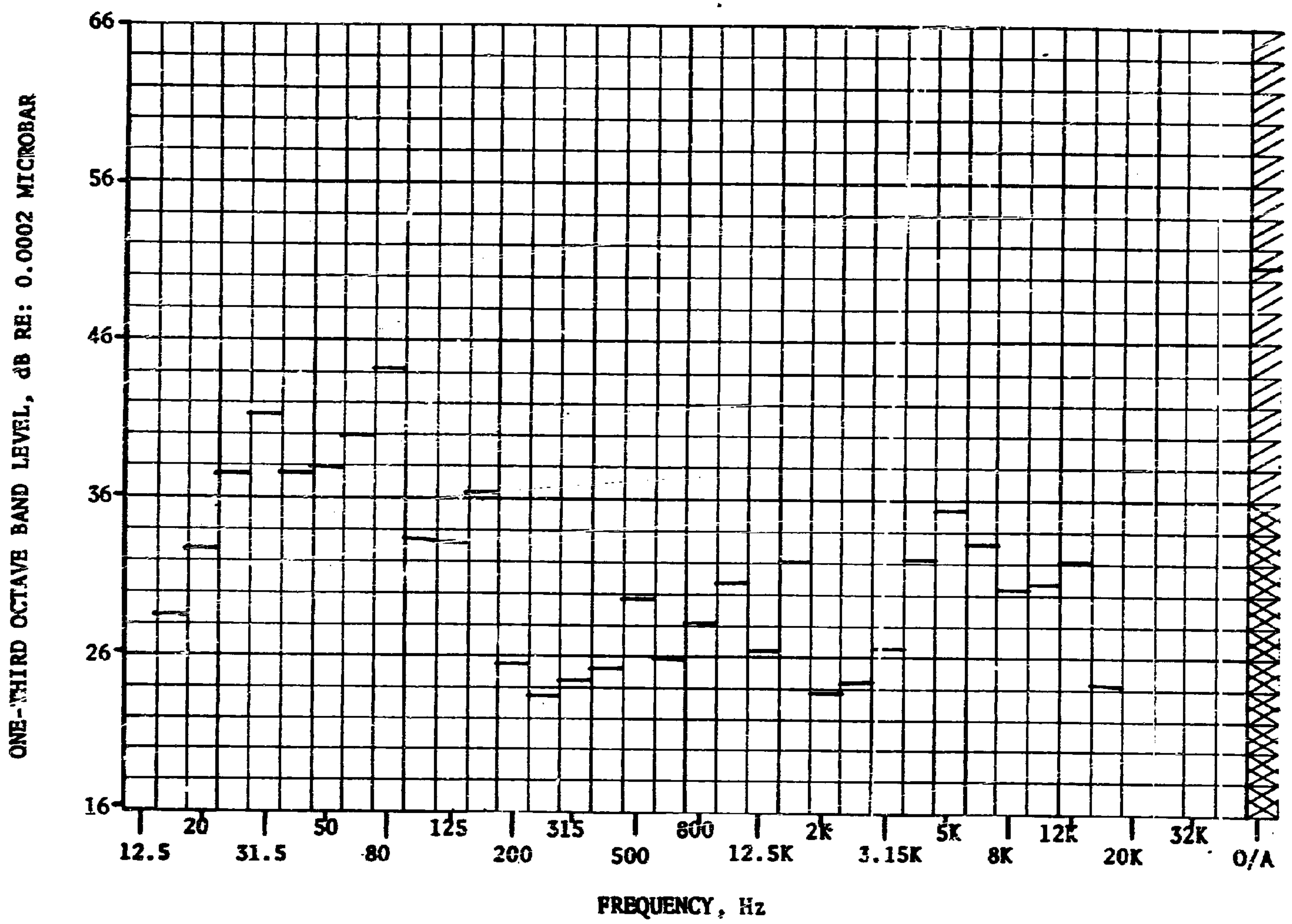

FIG 17.- ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 10 SEPTEMBER 1969 (RECORD 40)

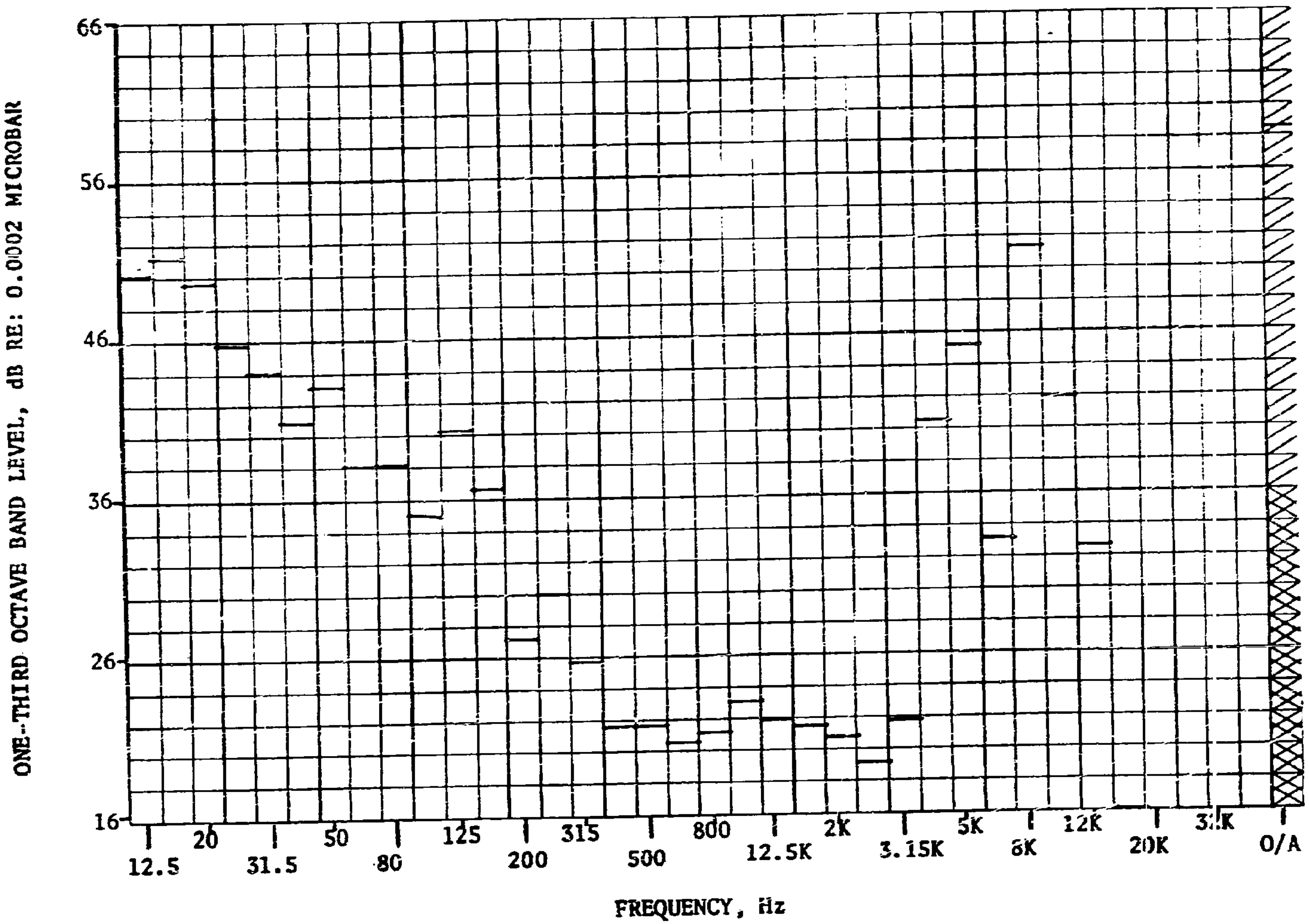

FIG 18. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 22 SEPTEMBER 1969 (RECORD 43)

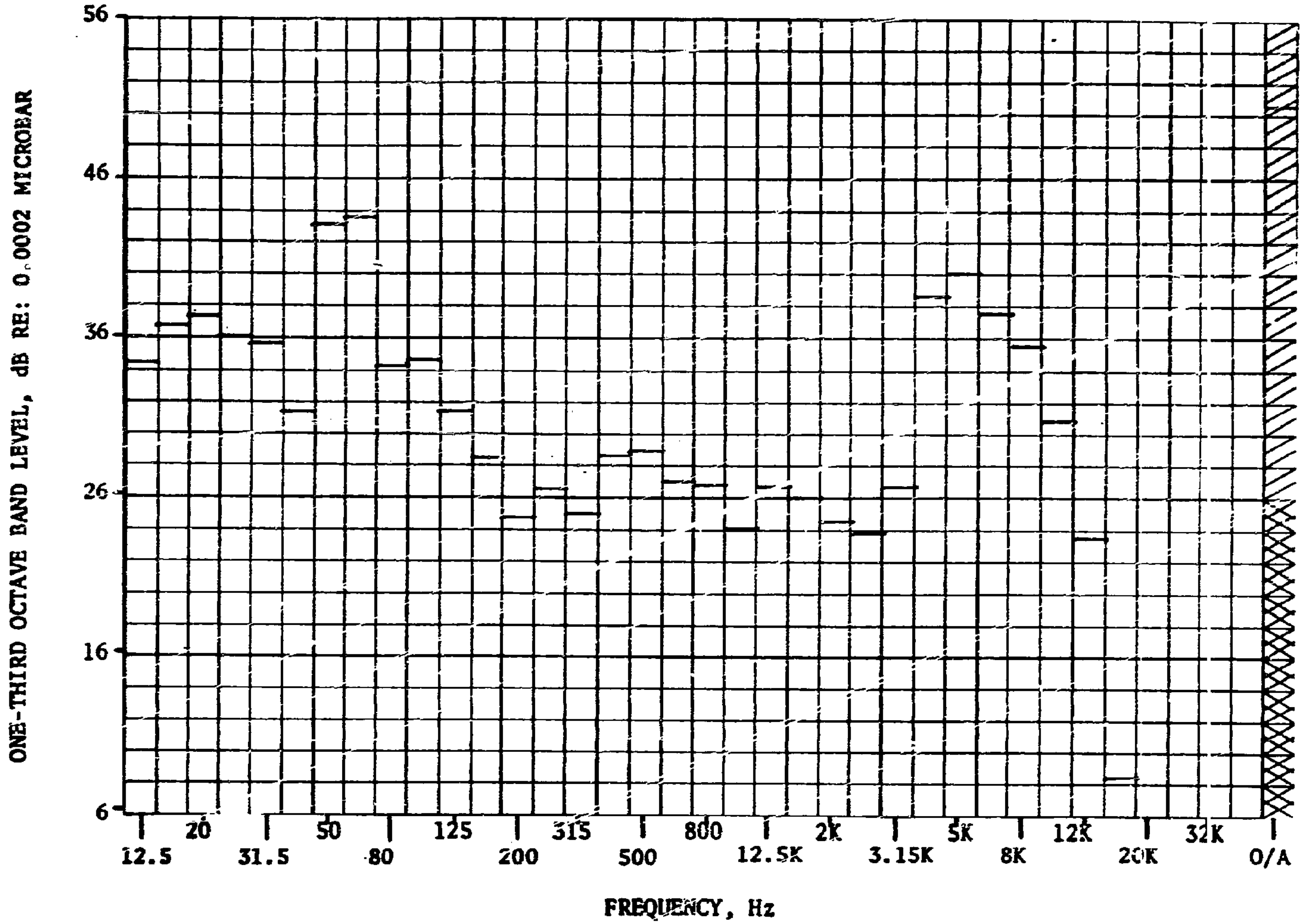

FIG 19. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 22 SEPTEMBER 1969 (RECORD 59)

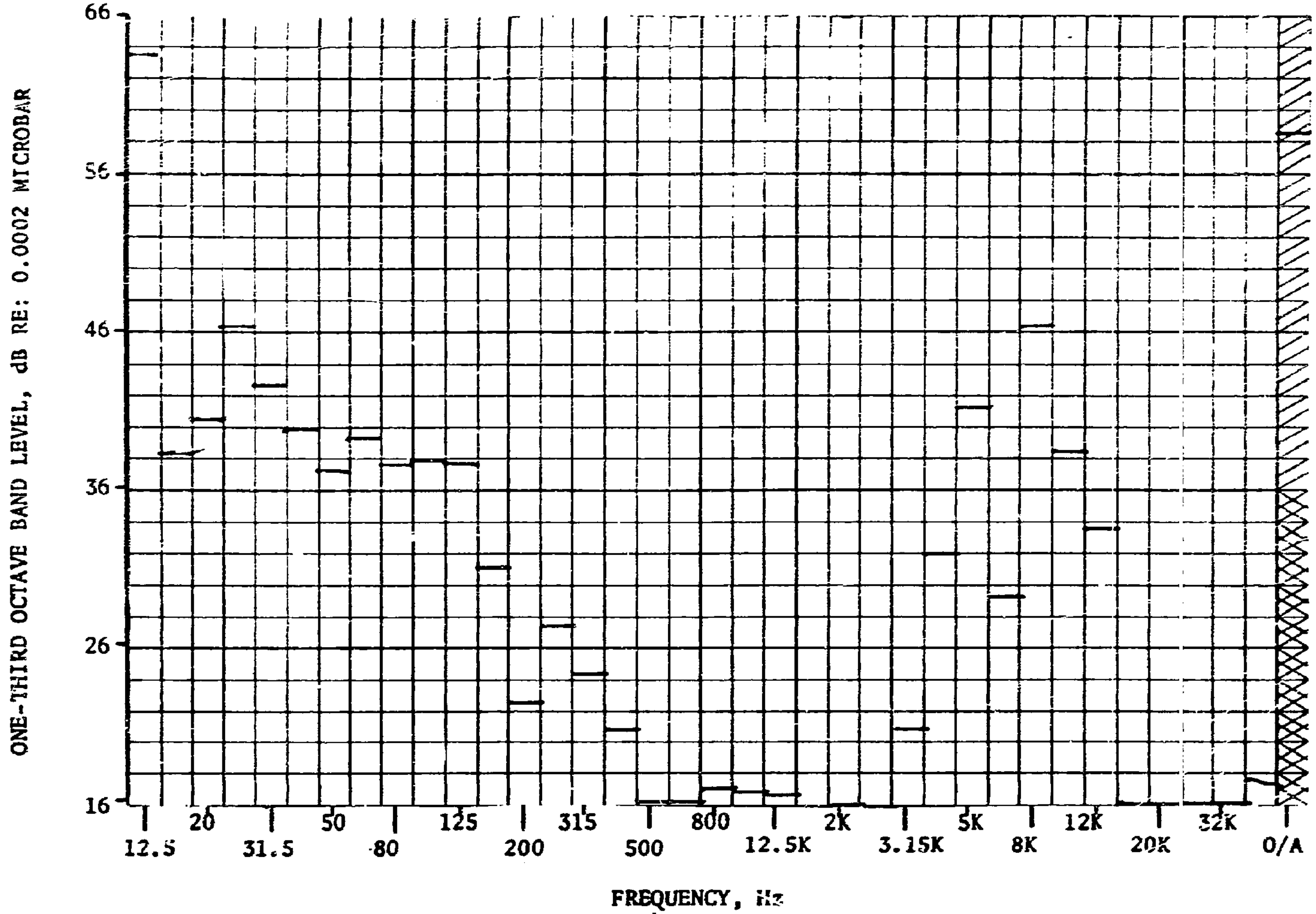

FIG 20. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 25 SEPTEMBER 1969 (RECORD 63)

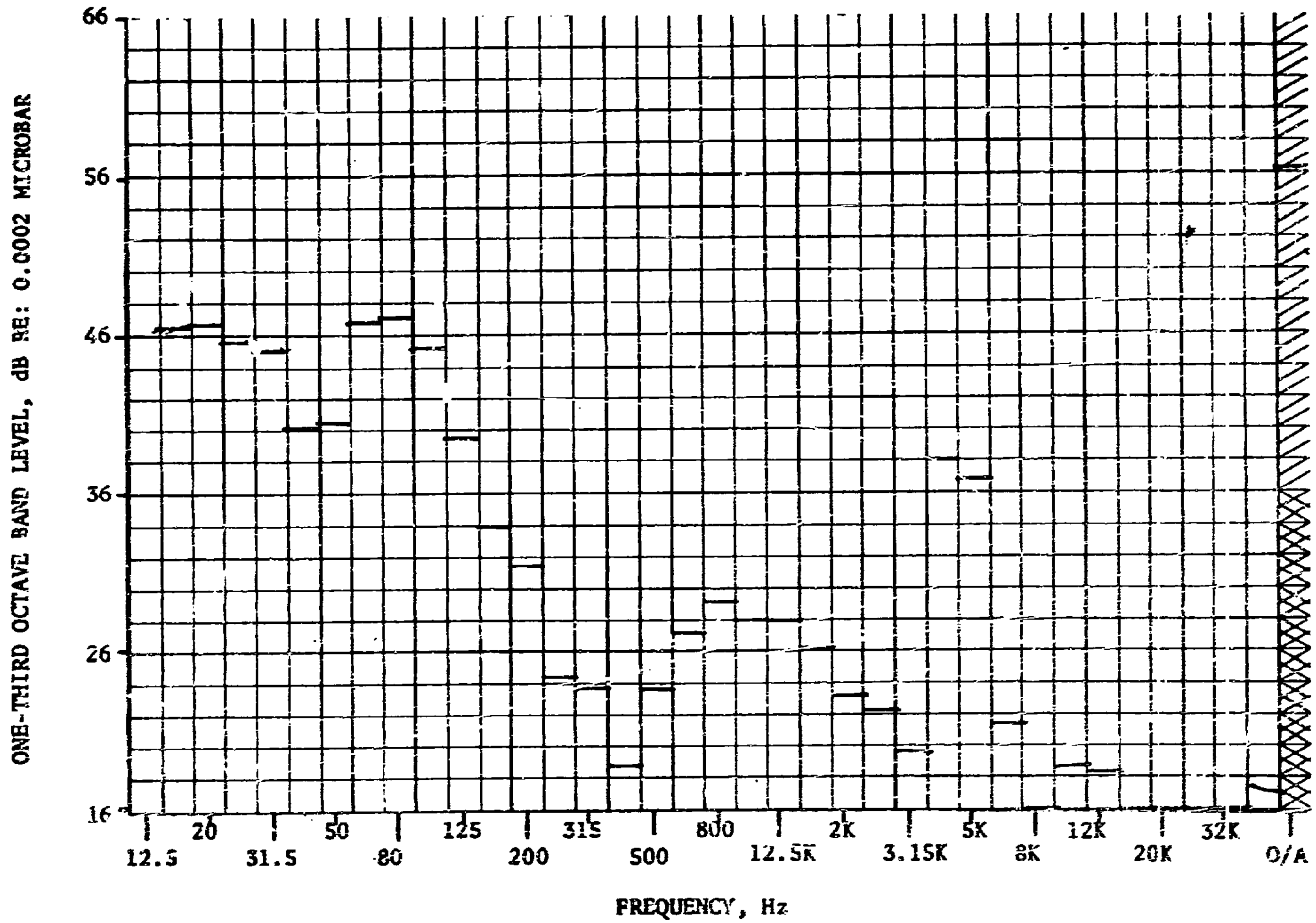

FIG 21. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 OF THE AMBIENT NOISE MEASURED AT RICHMOND MUNICIPAL AIRPORT ON 25 SEPTEMBER 1969 (RECORD 7)

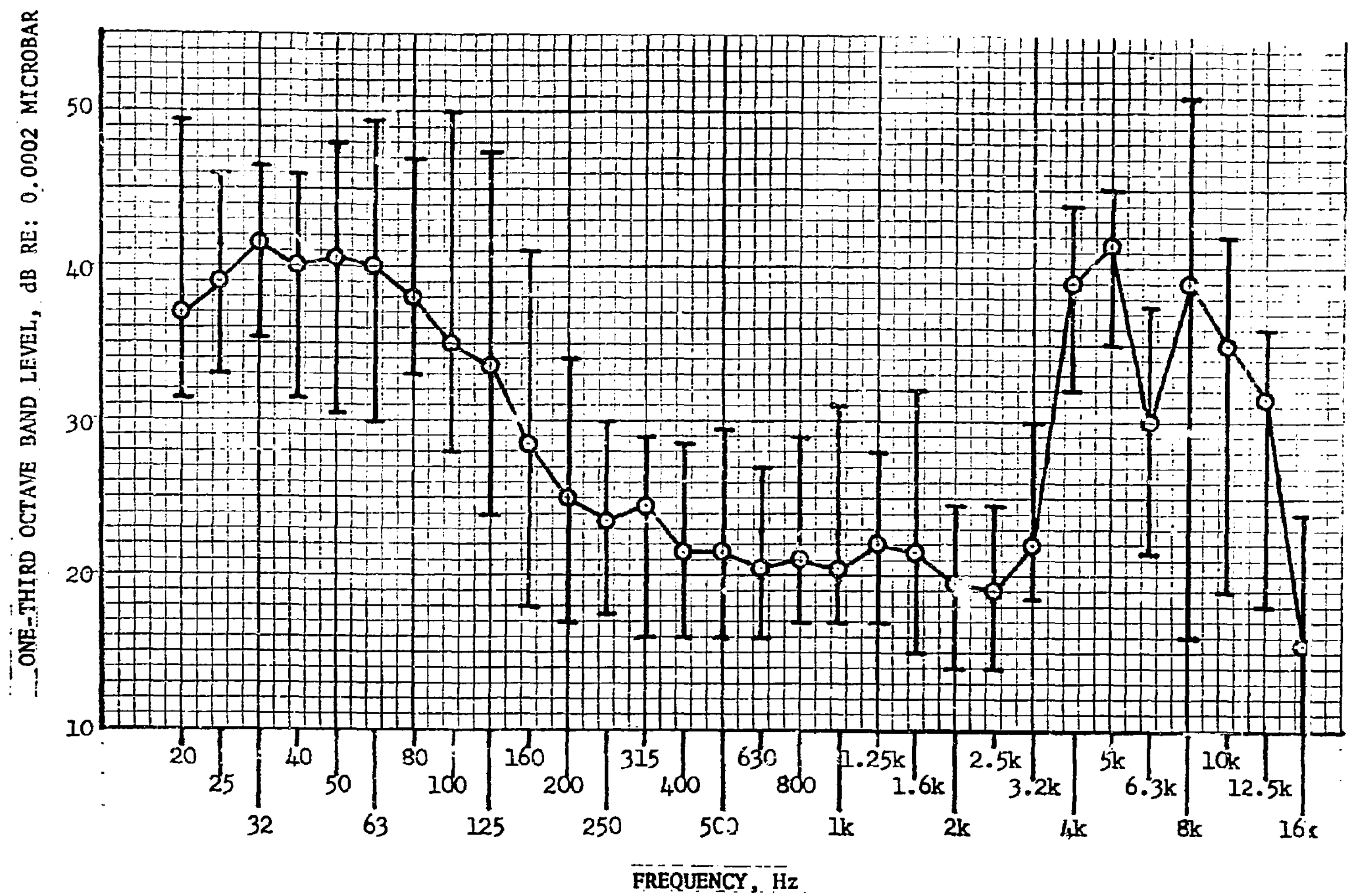

FIG 22. SUMMARY OF AMBIENT NOISE MEASUREMENTS MADE AT RICHMOND MUNICIPAL AIRPORT (MICROPHONE 1)

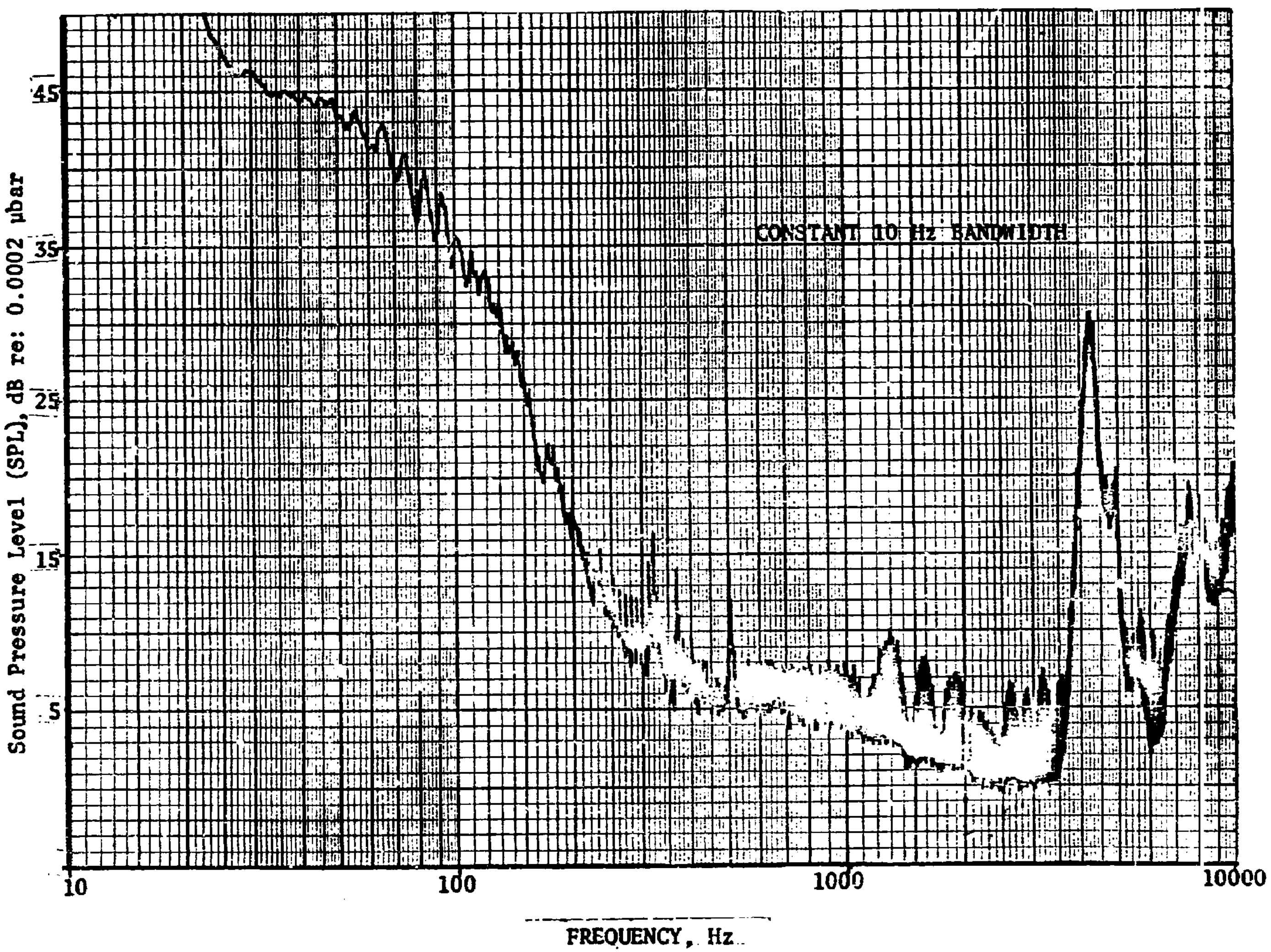

FIG 23. NARROW BAND ANALYSIS OF BACKGROUND NOISE ON 25 AUGUST USING DATA FROM MICROPHONE 1

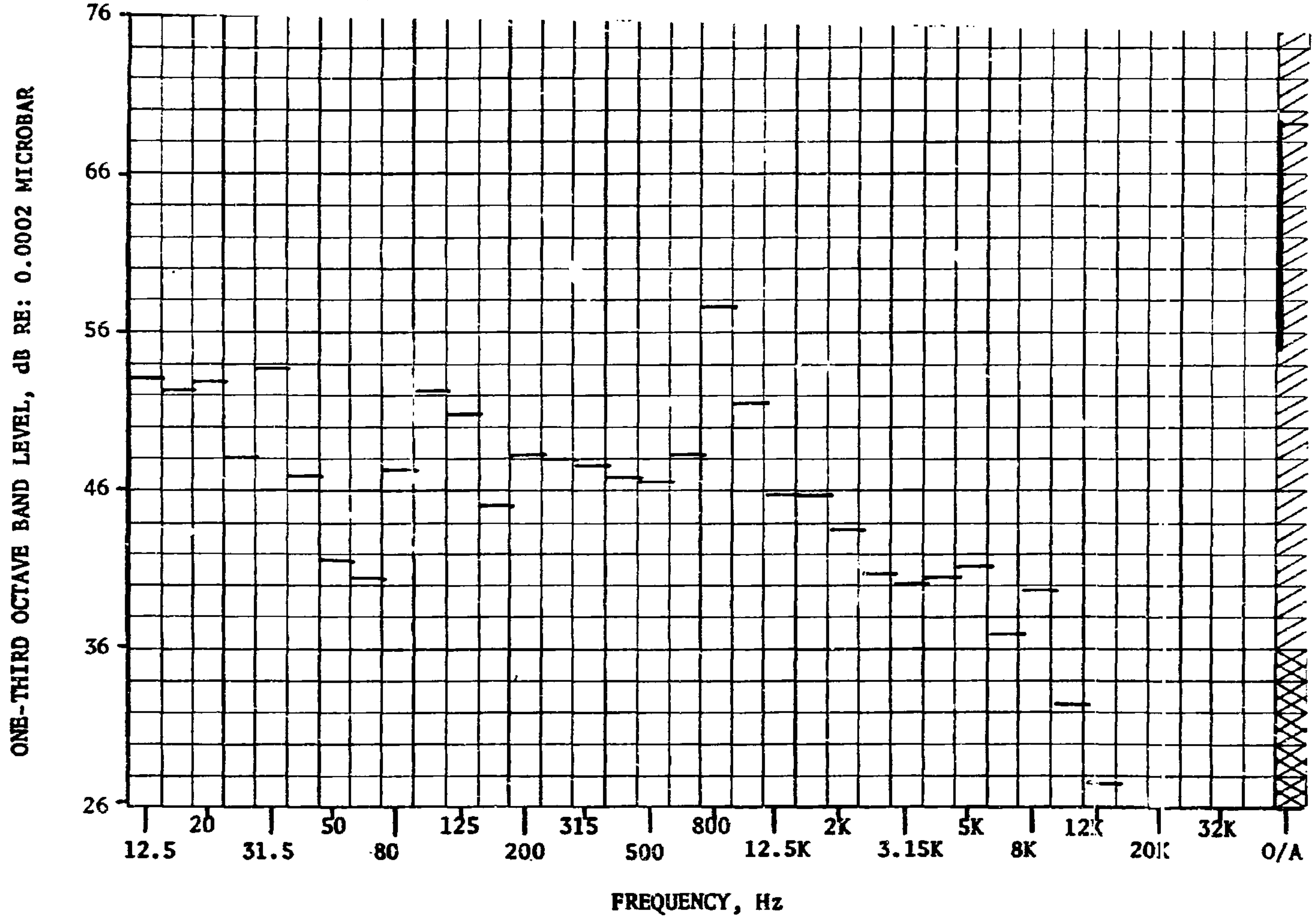

FIG 24. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 85 FOOT ALTITUDE AND AT A VELOCITY OF 88 FT/SEC

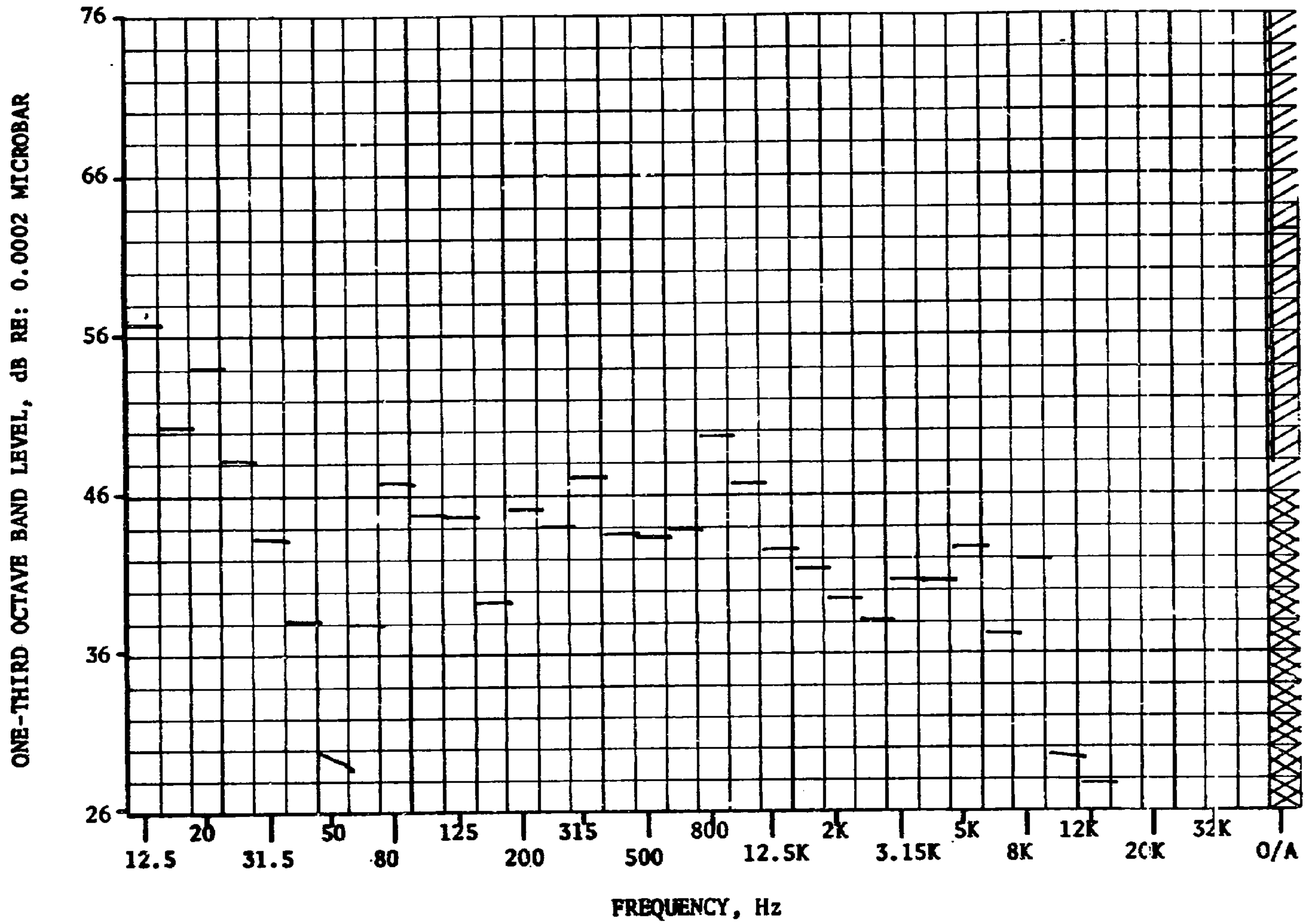

FIG 25. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 120 FOOT ALTITUDE AND AT A VELOCITY OF 110 FT/SEC

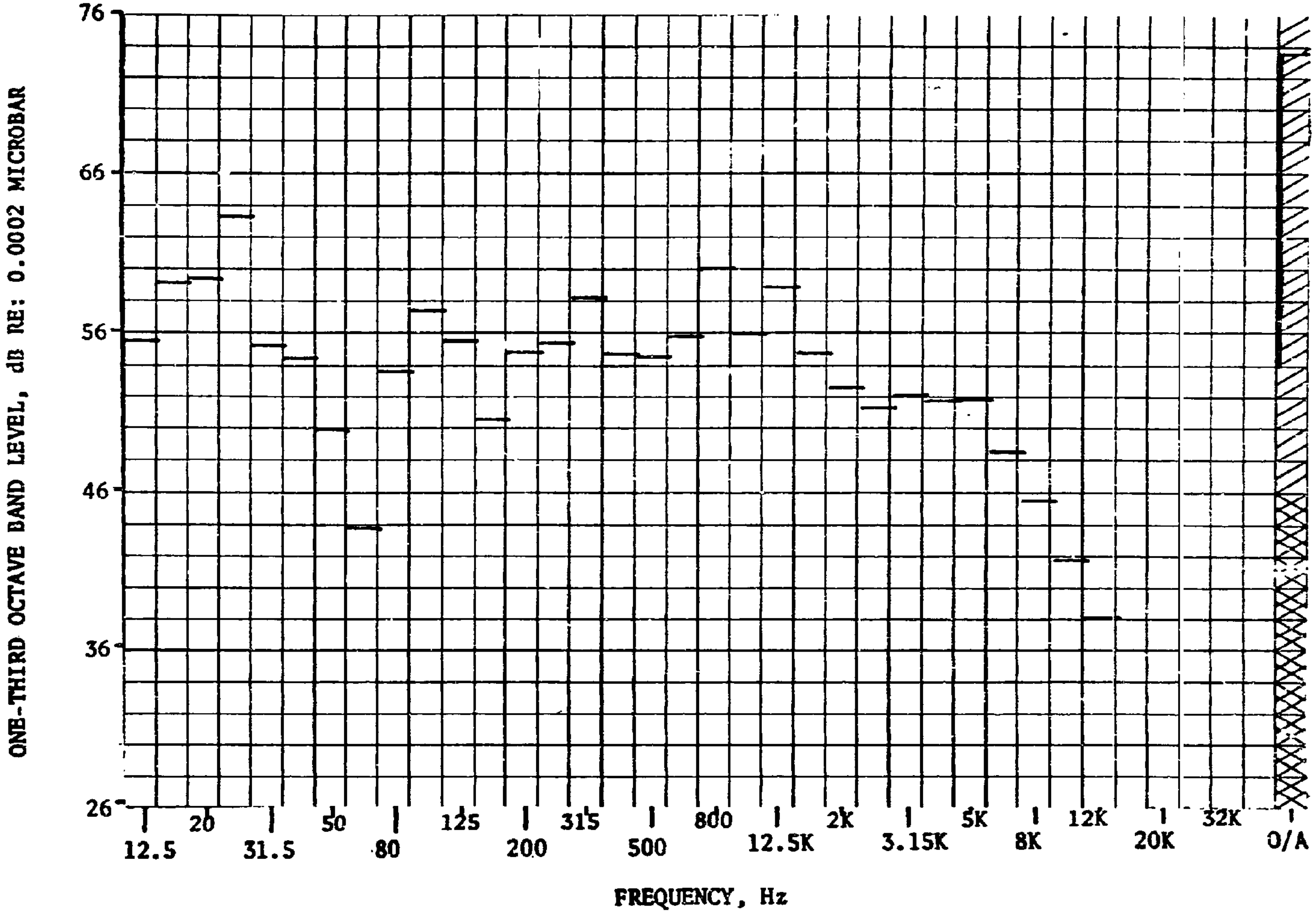

FIG 26. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 85 FOOT ALTITUDE AND AT A VELOCITY OF 132 FT/SEC

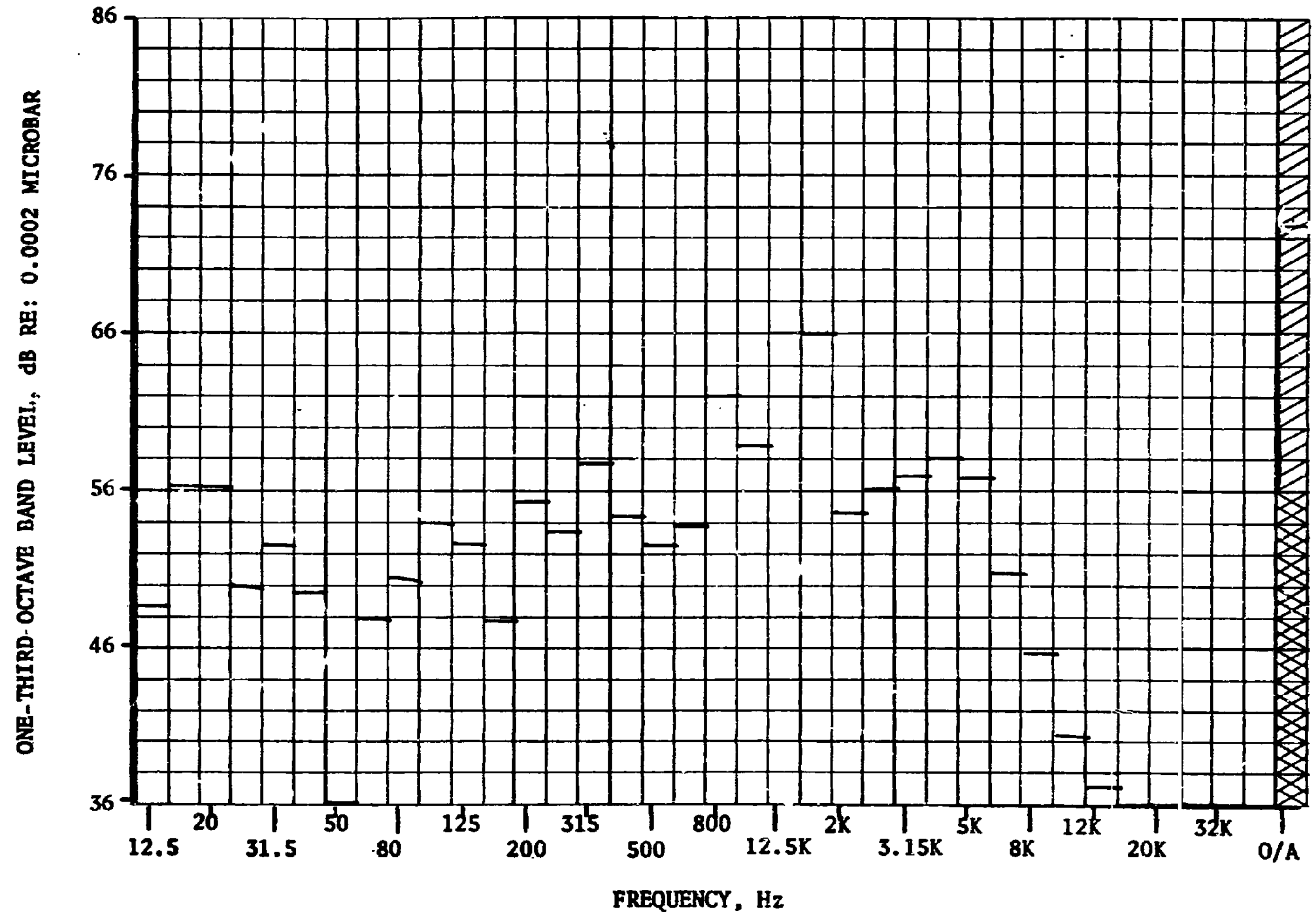

FIG 27. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 95 FOOT ALTITUDE AND AT A VELOCITY OF 147 FT/SEC

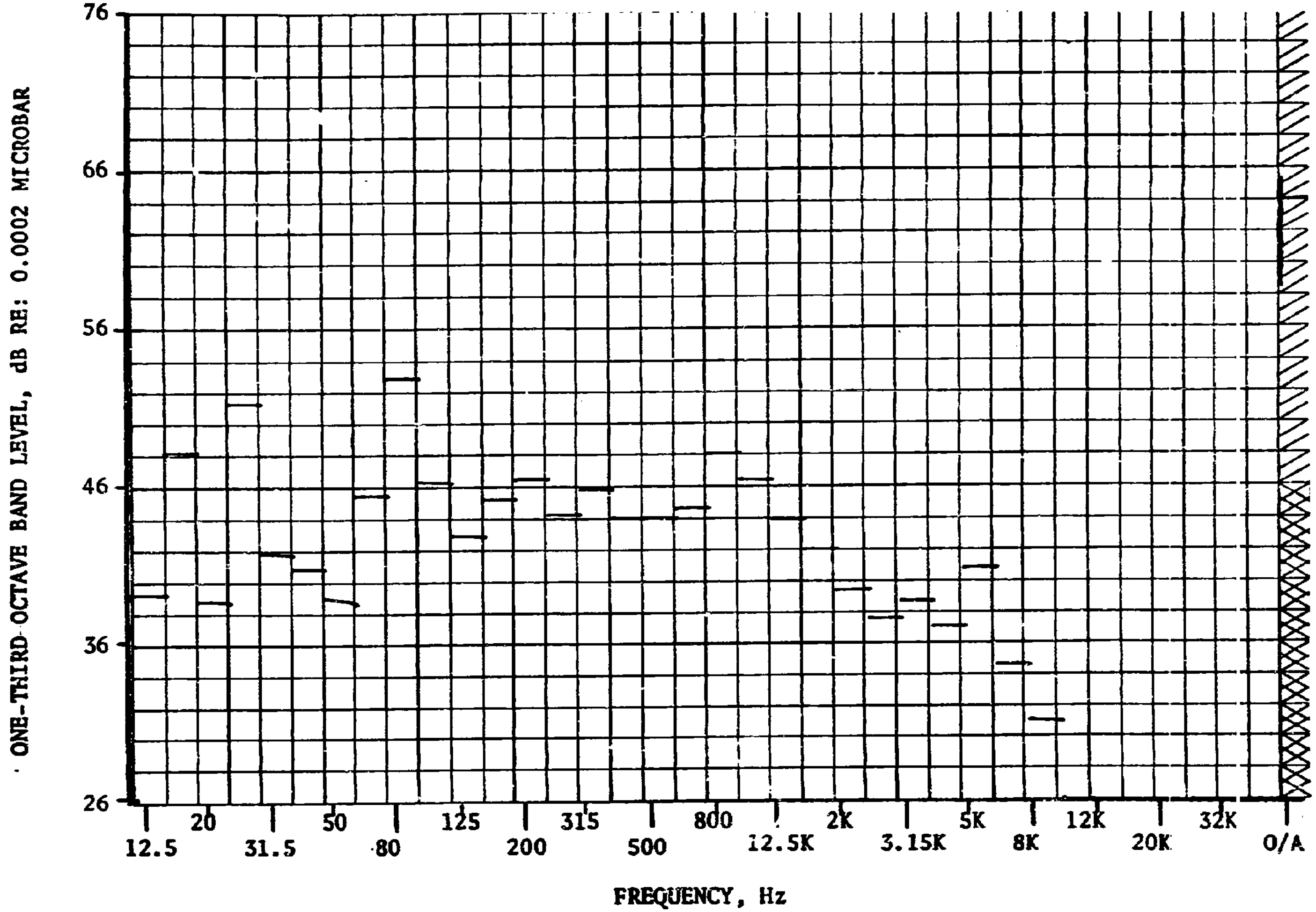

FIG 28. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 80 FOOT ALTITUDE AND AT A VELOCITY OF 103 FT/SEC

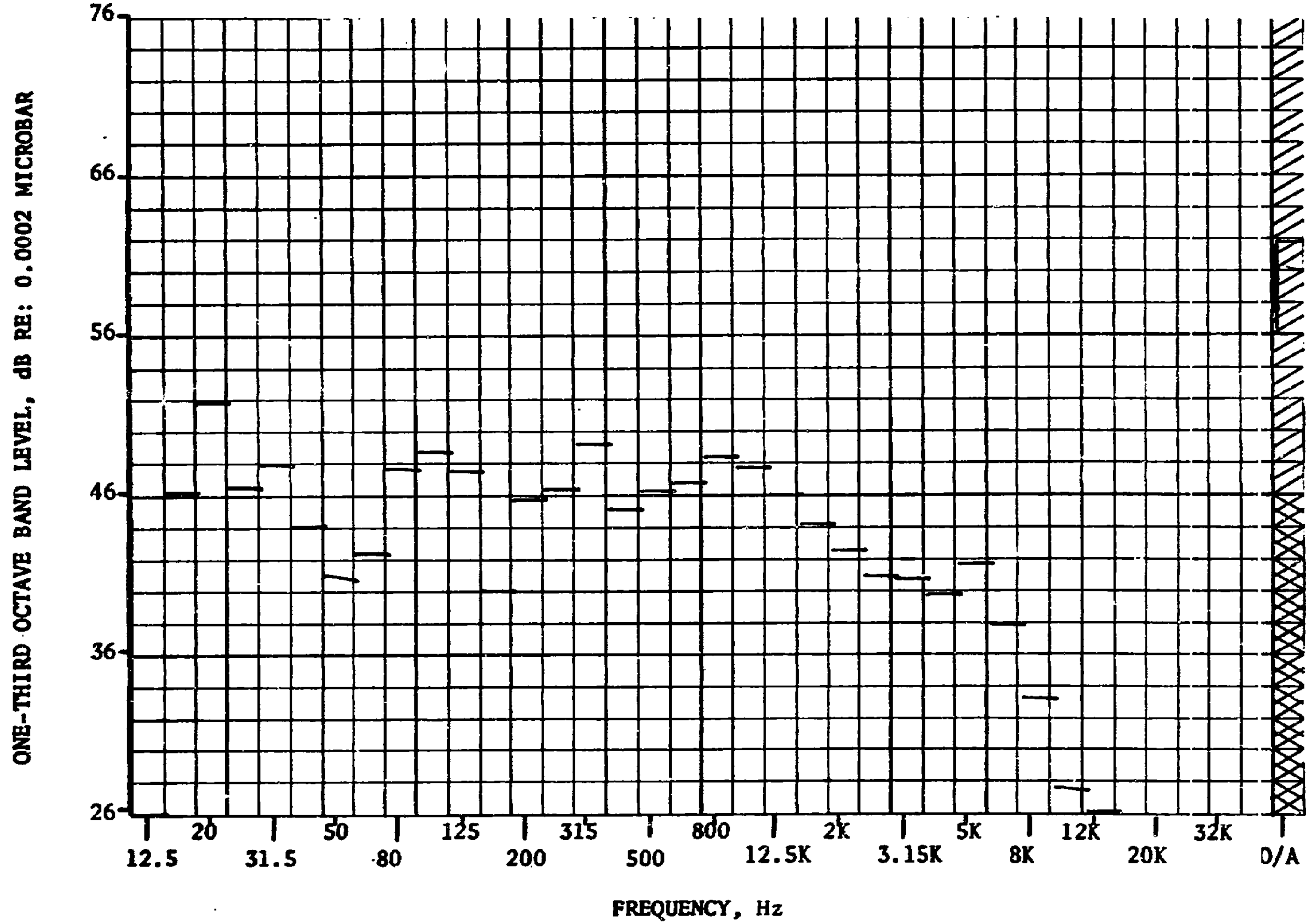

FIG 29. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 130 FOOT ALTITUDE AND AT A VELOCITY OF 117 FT/SEC

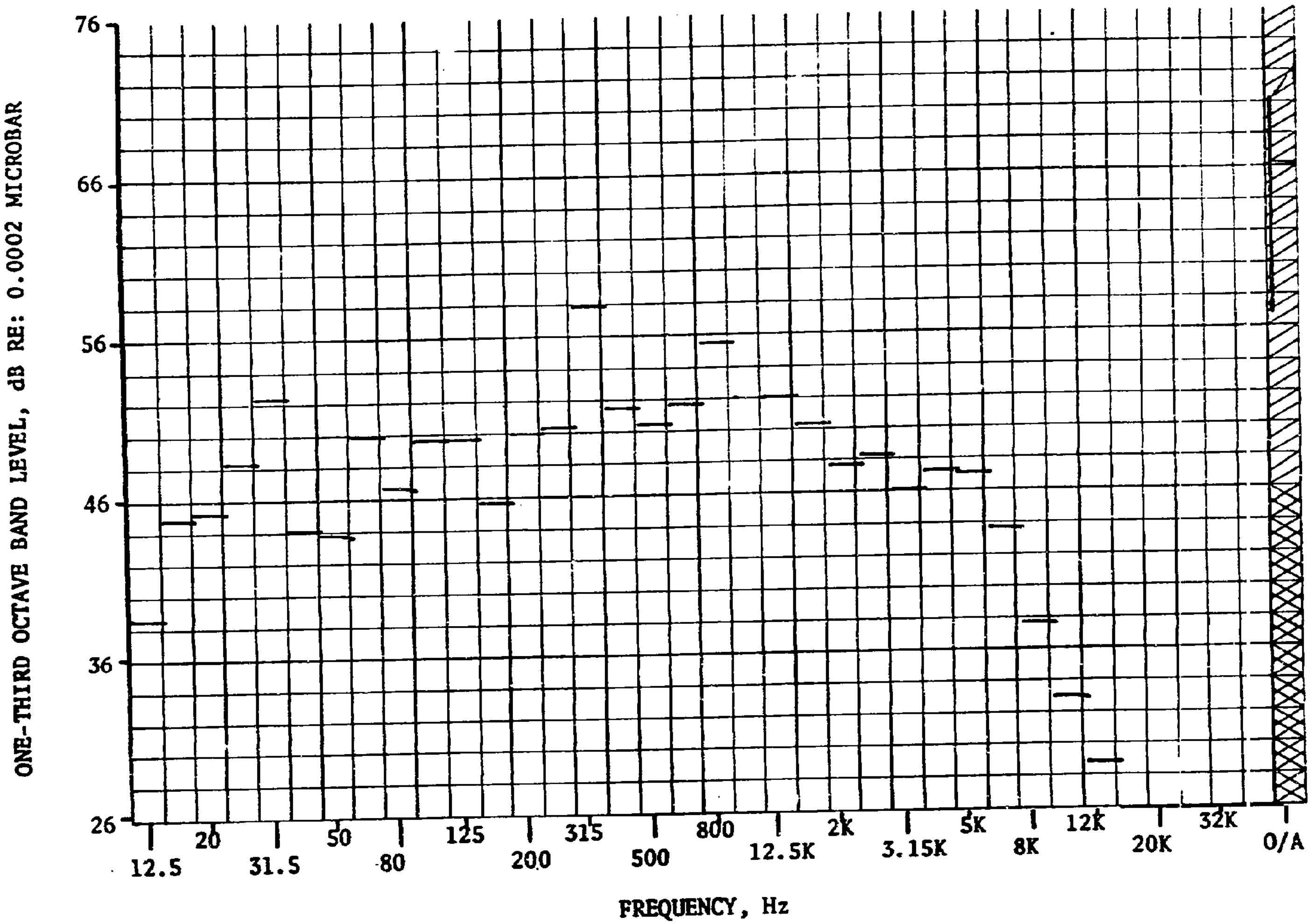

FIG 30. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 110 FOOT ALTITUDE AND AT A VELOCITY OF 132 FT/SEC

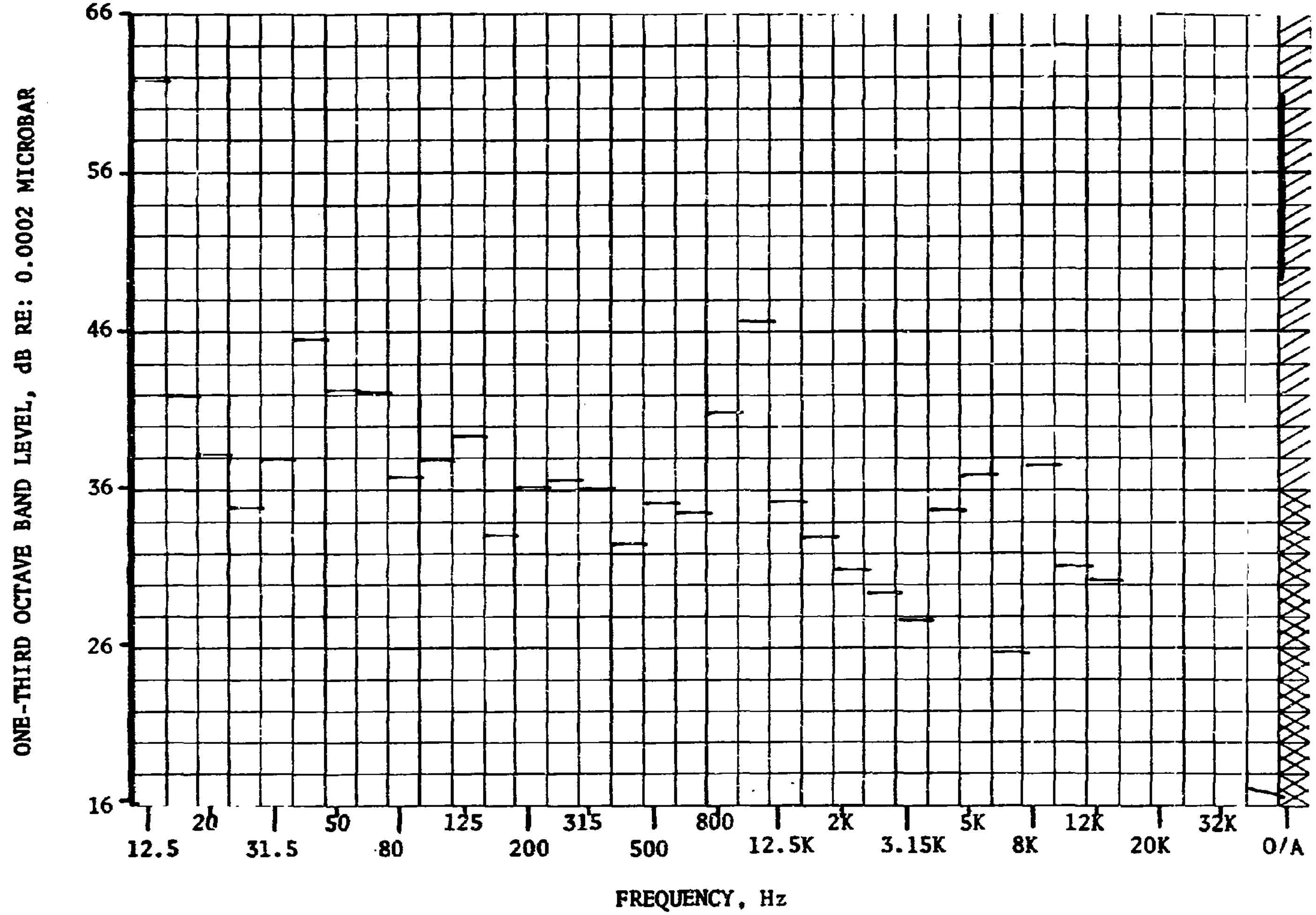

FIG 31. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 80 FOOT ALTITUDE AND AT A VELOCITY OF 95 FT/SEC

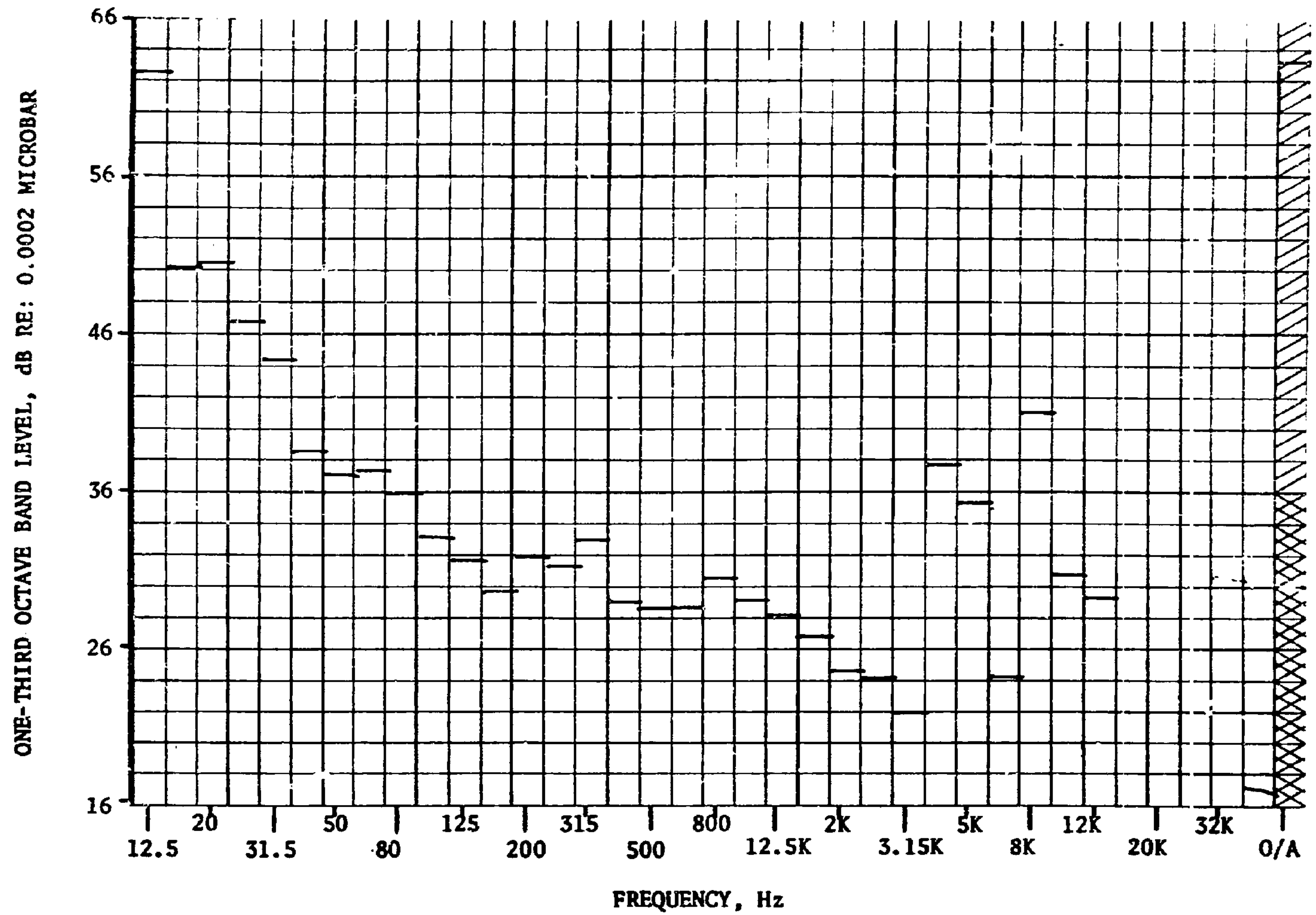

FIG 32. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 413 FOOT ALTITUDE AND AT A VELOCITY OF 129 FT/SEC

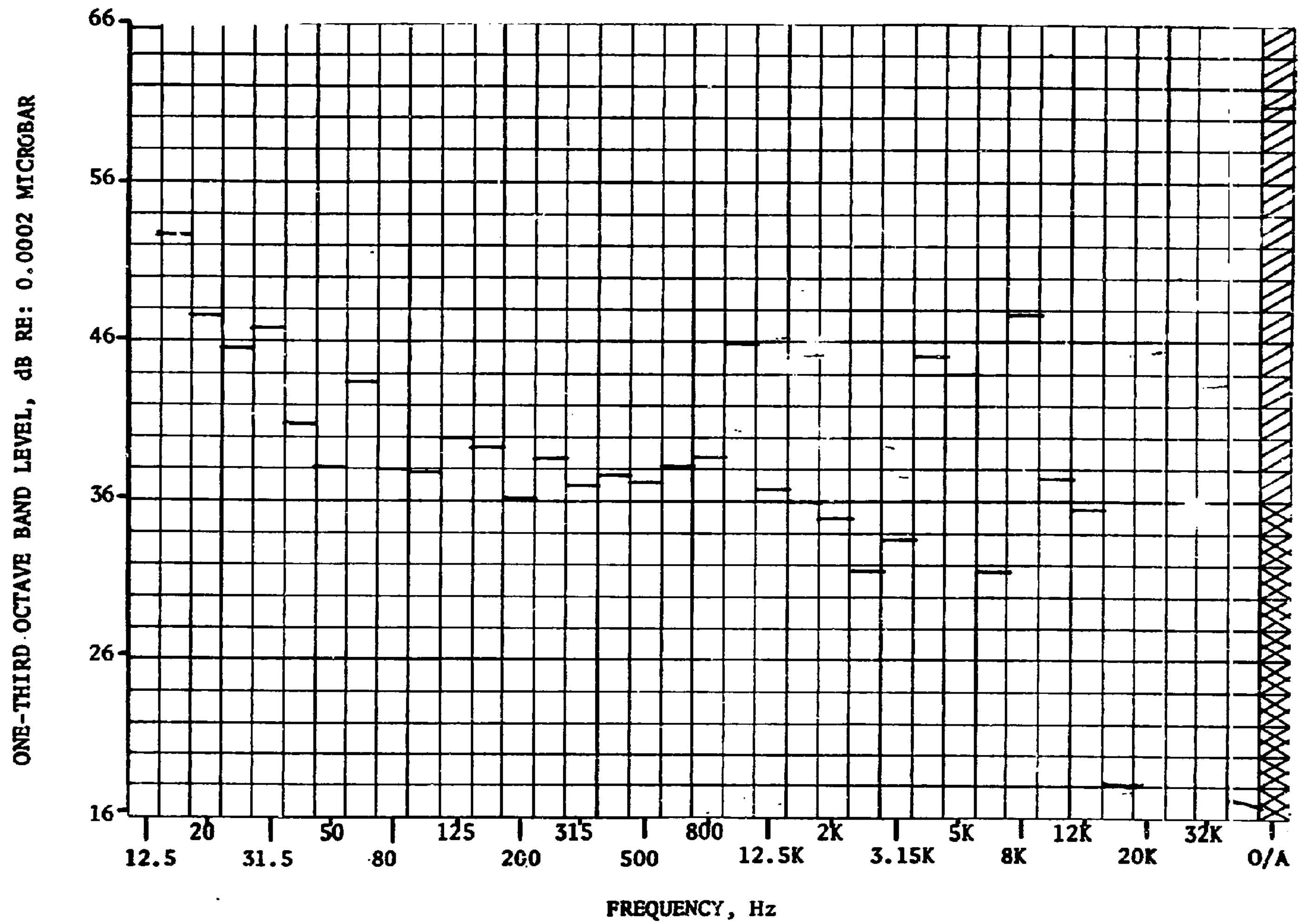

FIG 33. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 150 FOOT ALTITUDE AND AT A VELOCITY OF 95 FT/SEC

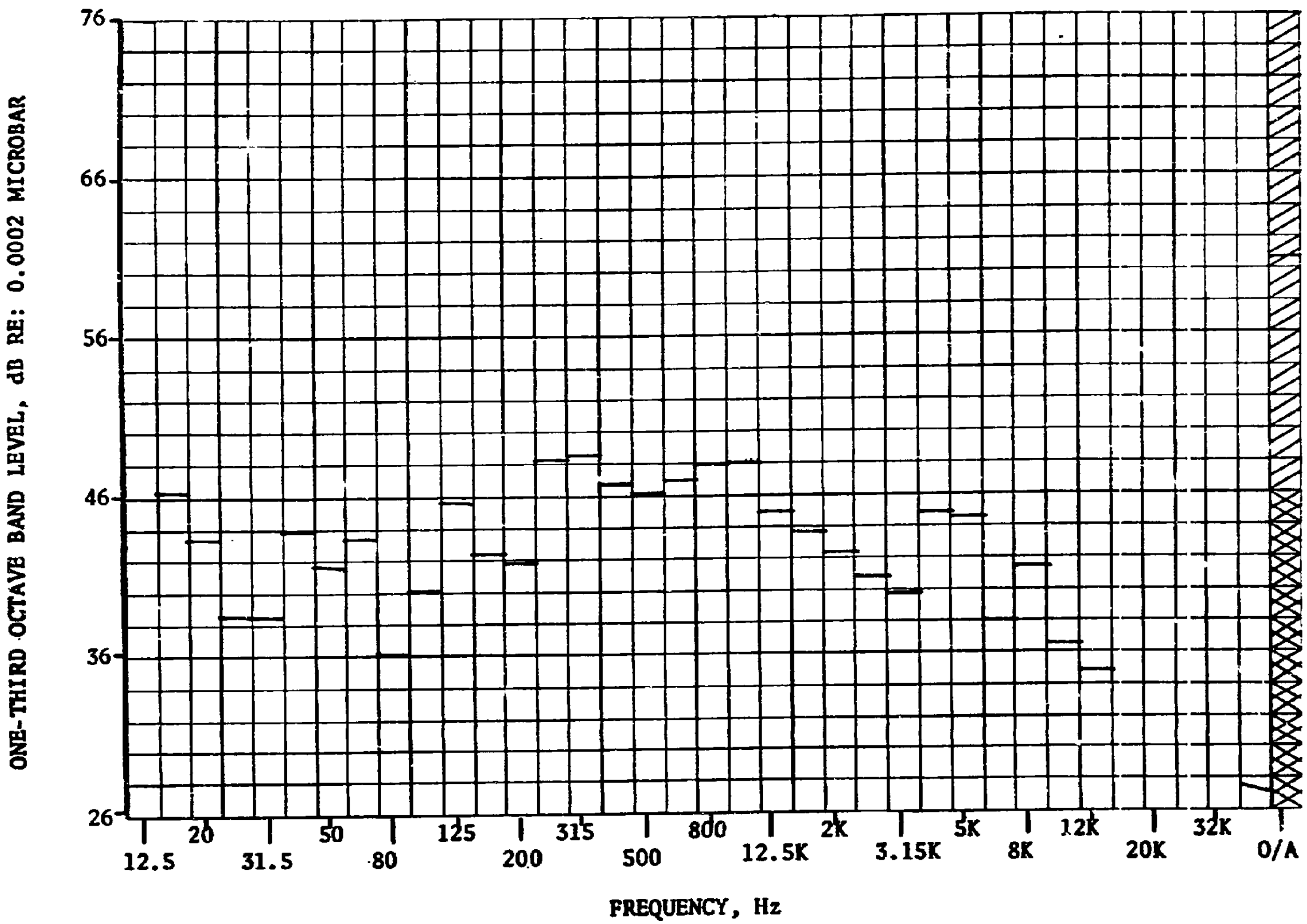

FIG 34. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 89 FOOT ALTITUDE AND AT A VELOCITY OF 123 FT/SEC

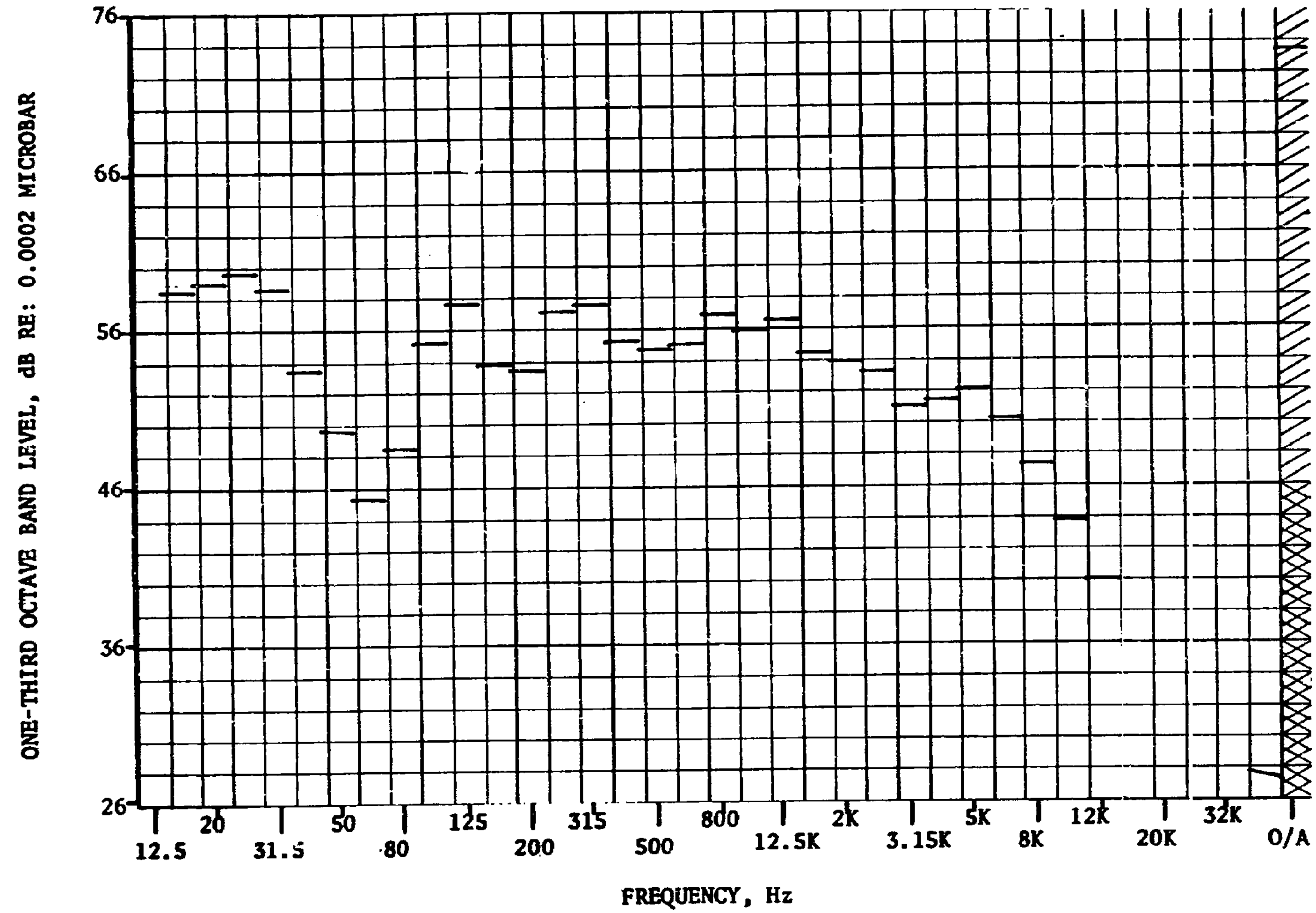

FIG 35. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 32 FOOT ALTITUDE AND AT A VELOCITY OF 110 FT/SEC

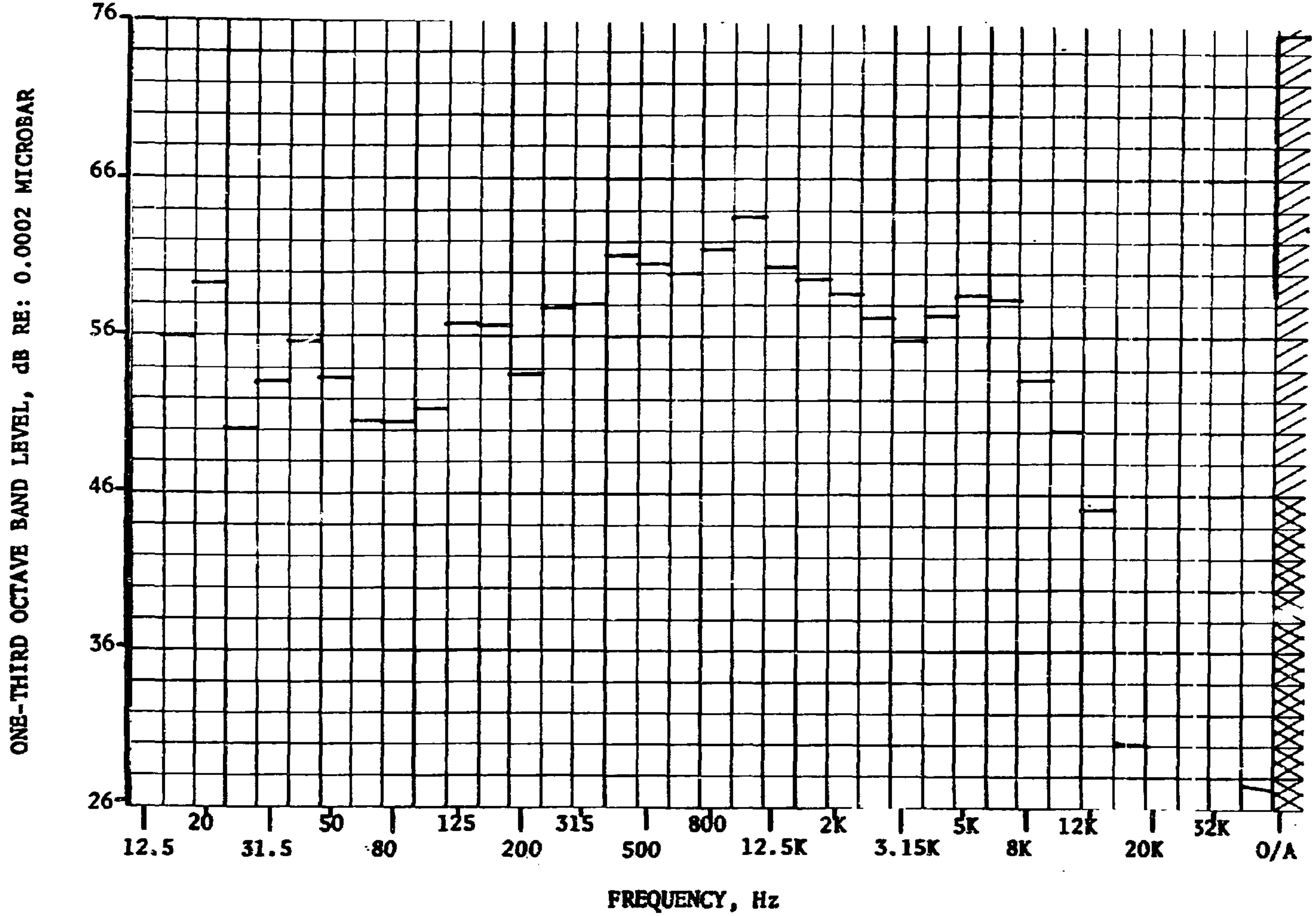

FIG 36. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 47 FOOT ALTITUDE AND AT A VELOCITY OF 183 FT/SEC

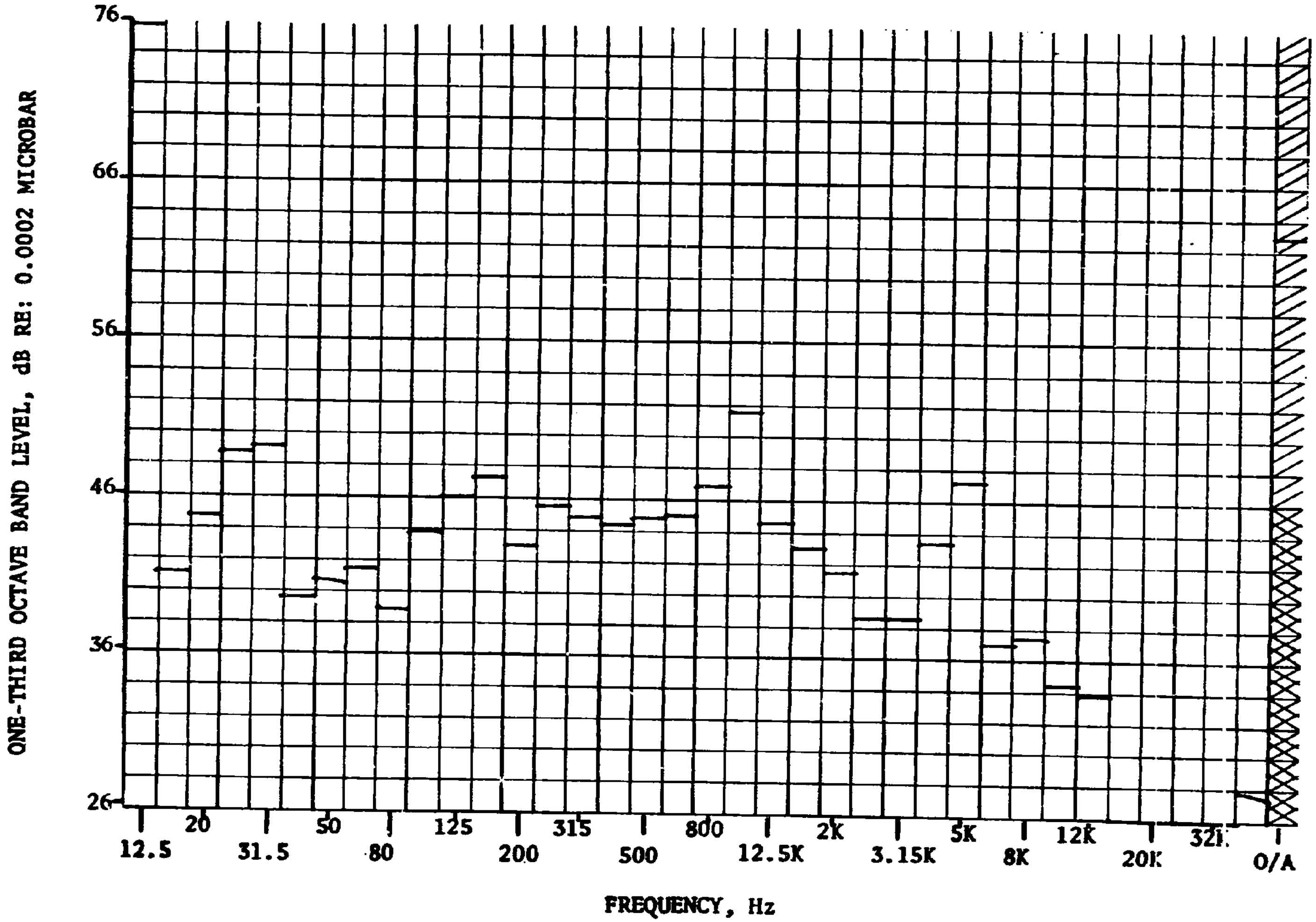

FIG 37. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 66 FOOT ALTITUDE AND AT A VELOCITY OF 120 FT/SEC

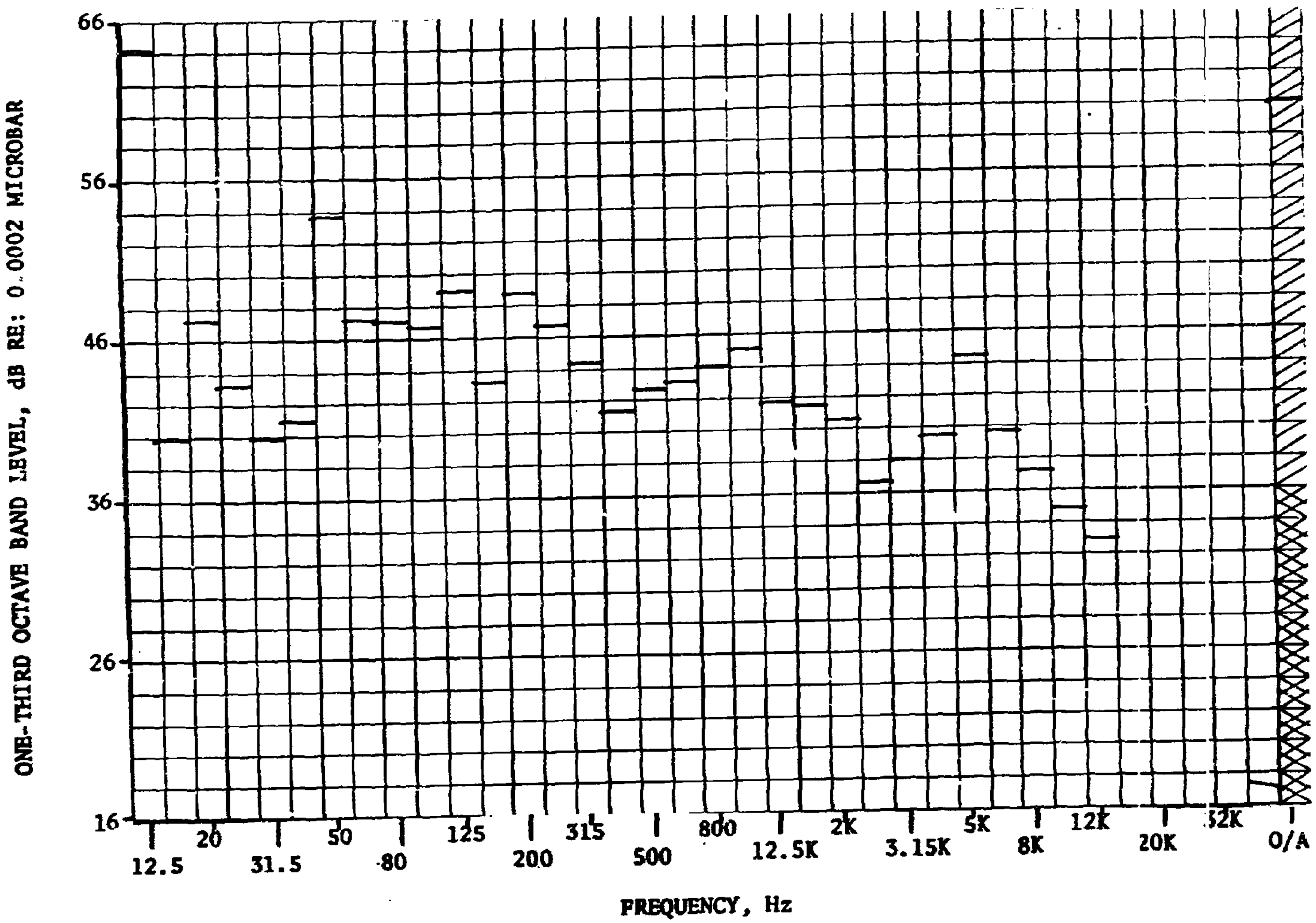

FIG 38. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 88 FOOT ALTITUDE AND AT A VELOCITY OF 103 FT/SEC

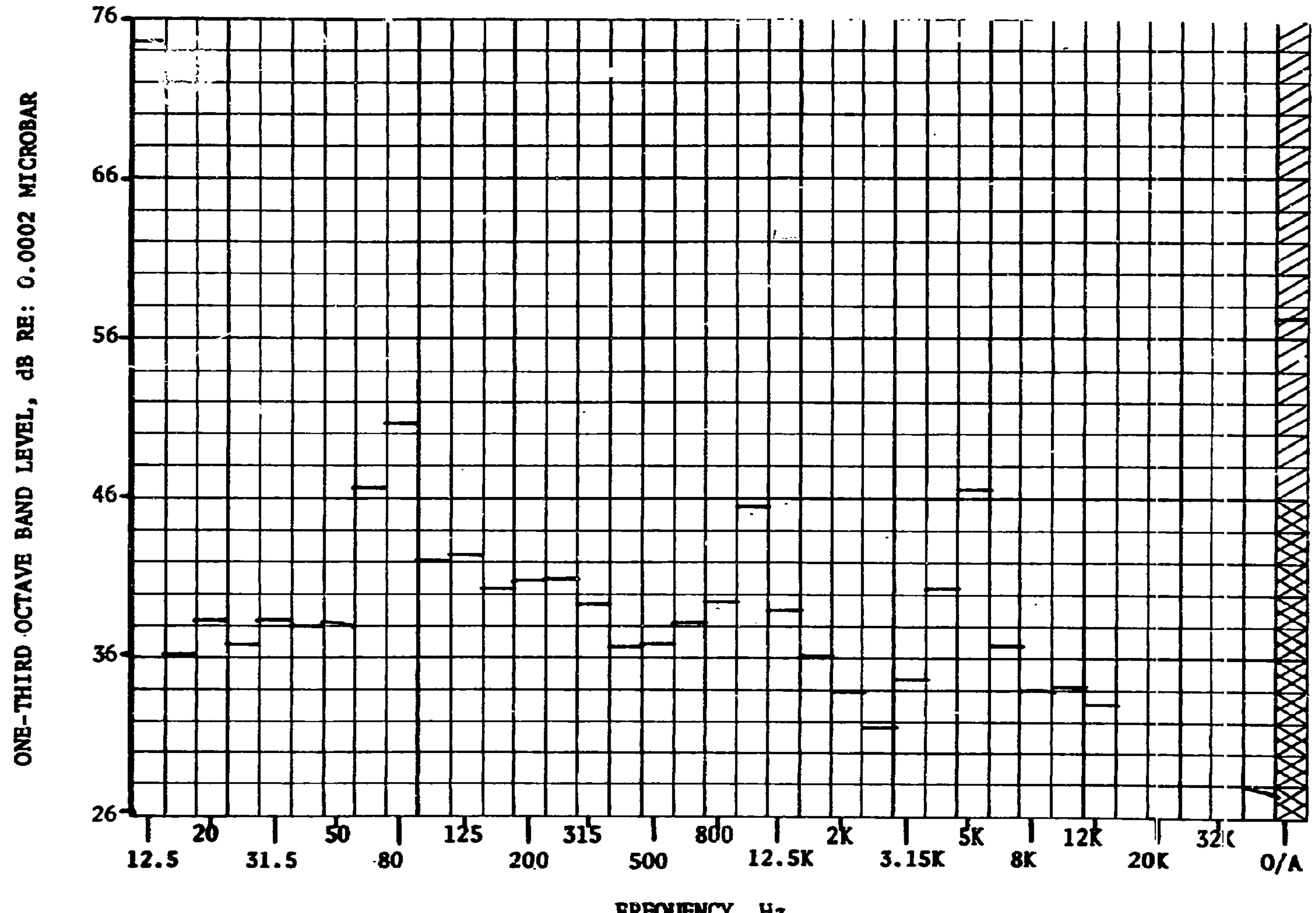

FIG 39. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 130 FOOT ALTITUDE AND AT A VELOCITY OF 98 FT/SEC

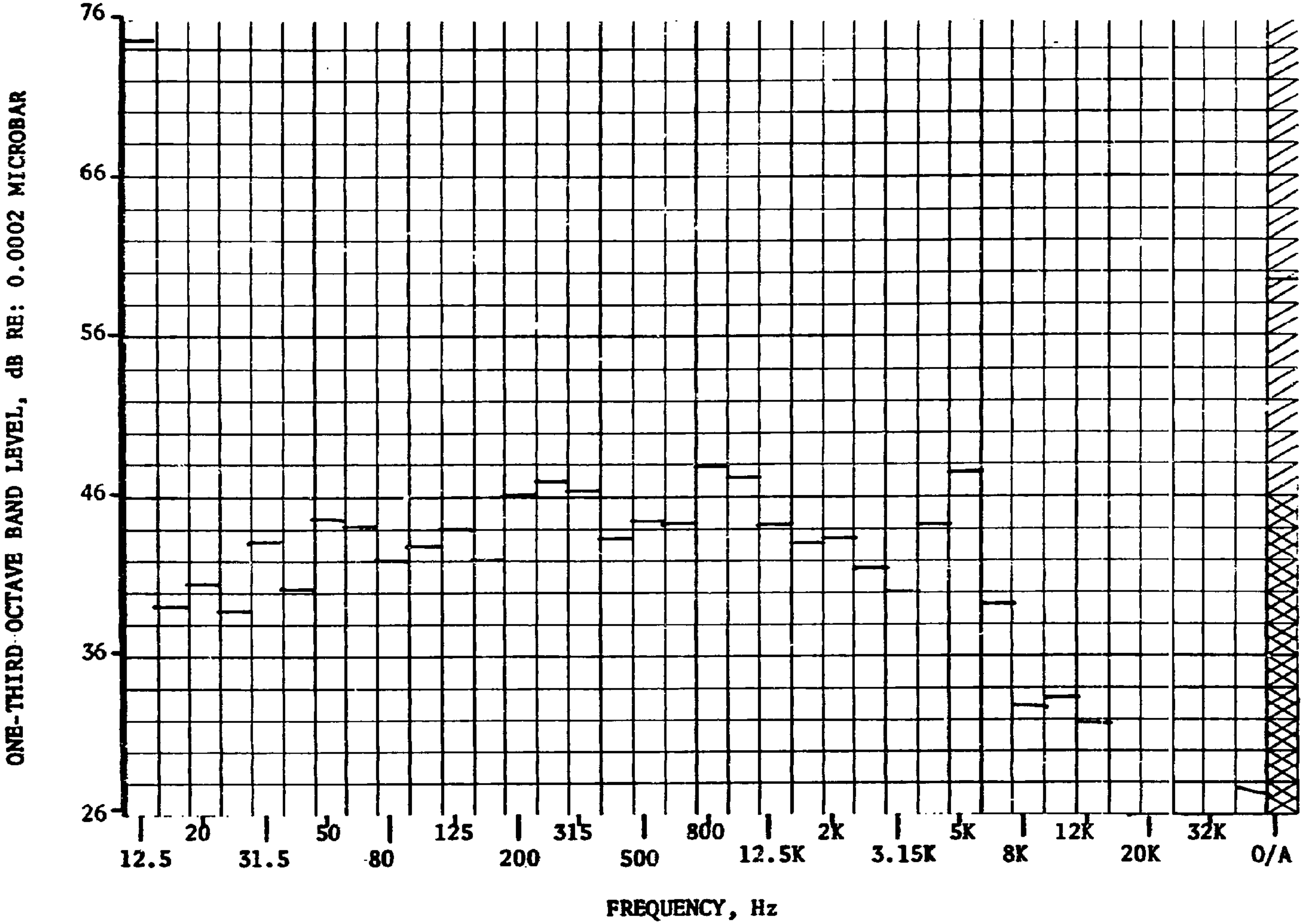

FIG 40. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 111 FOOT ALTITUDE AND AT A VELOCITY OF 133 FT/SEC

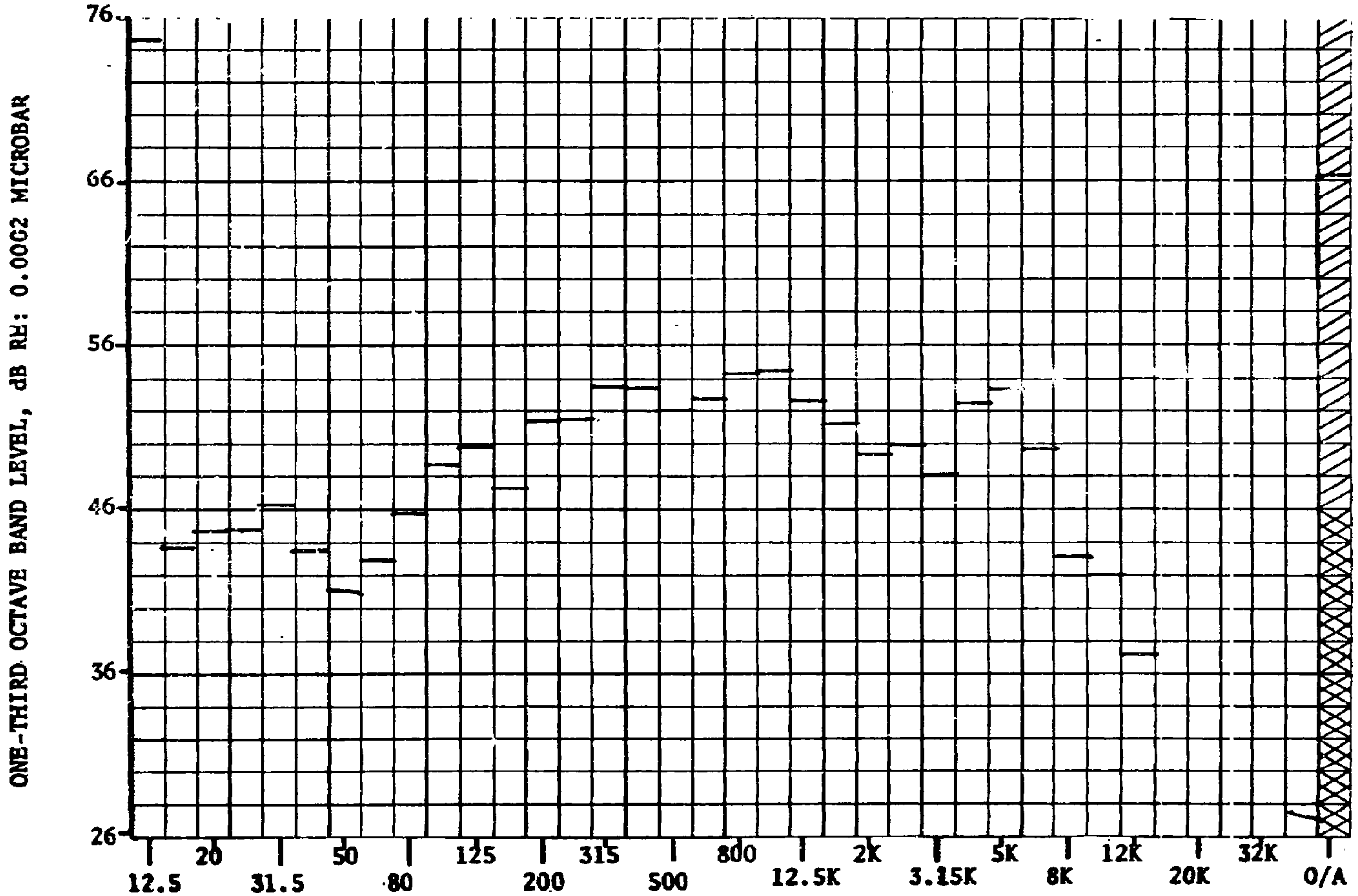

FIG 41. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 87 FOOT ALTITUDE AND AT A VELOCITY OF 161 FT/SEC

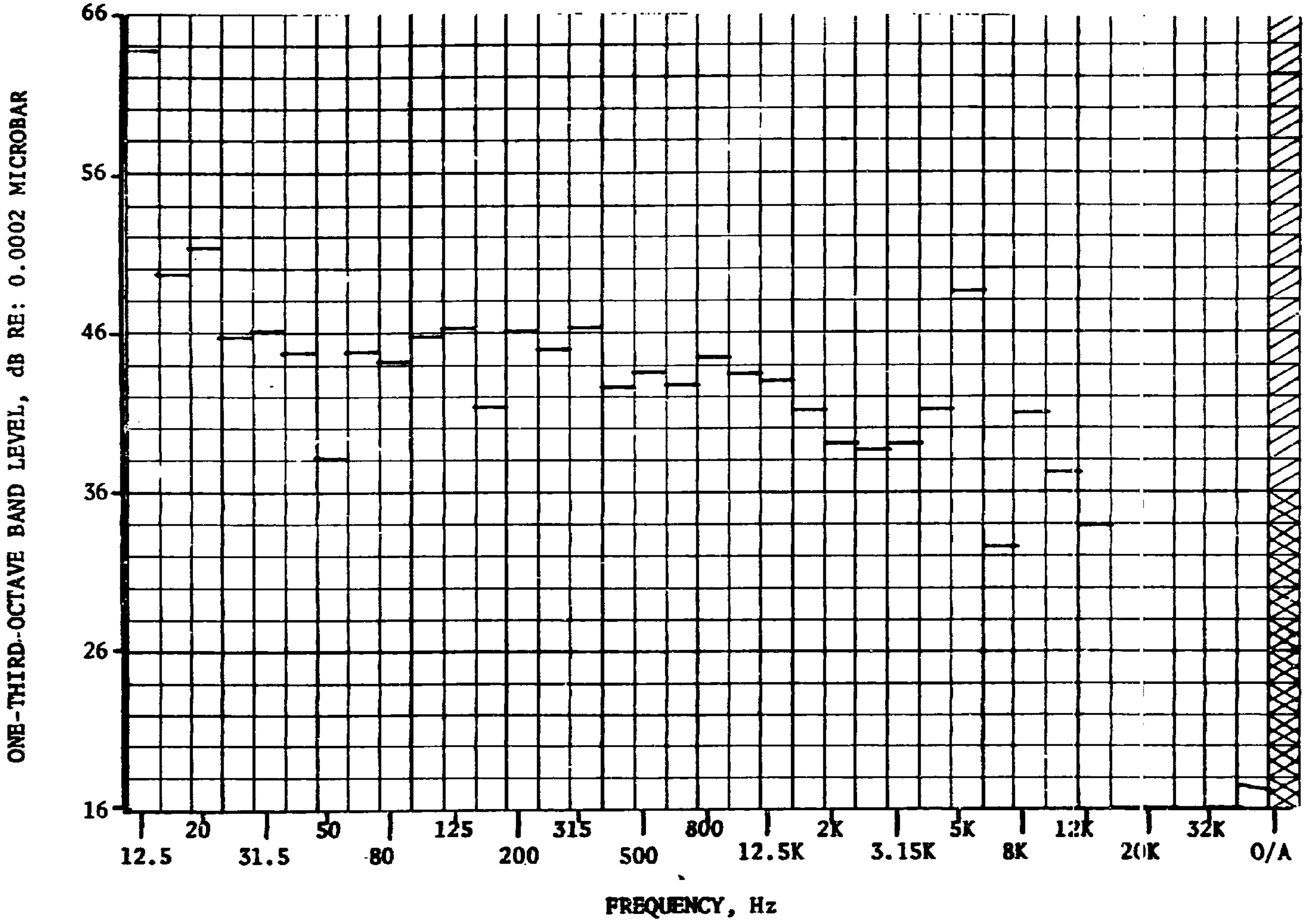

FIG 42. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 167 FOOT ALTITUDE AND AT A VELOCITY OF 113 FT/SEC

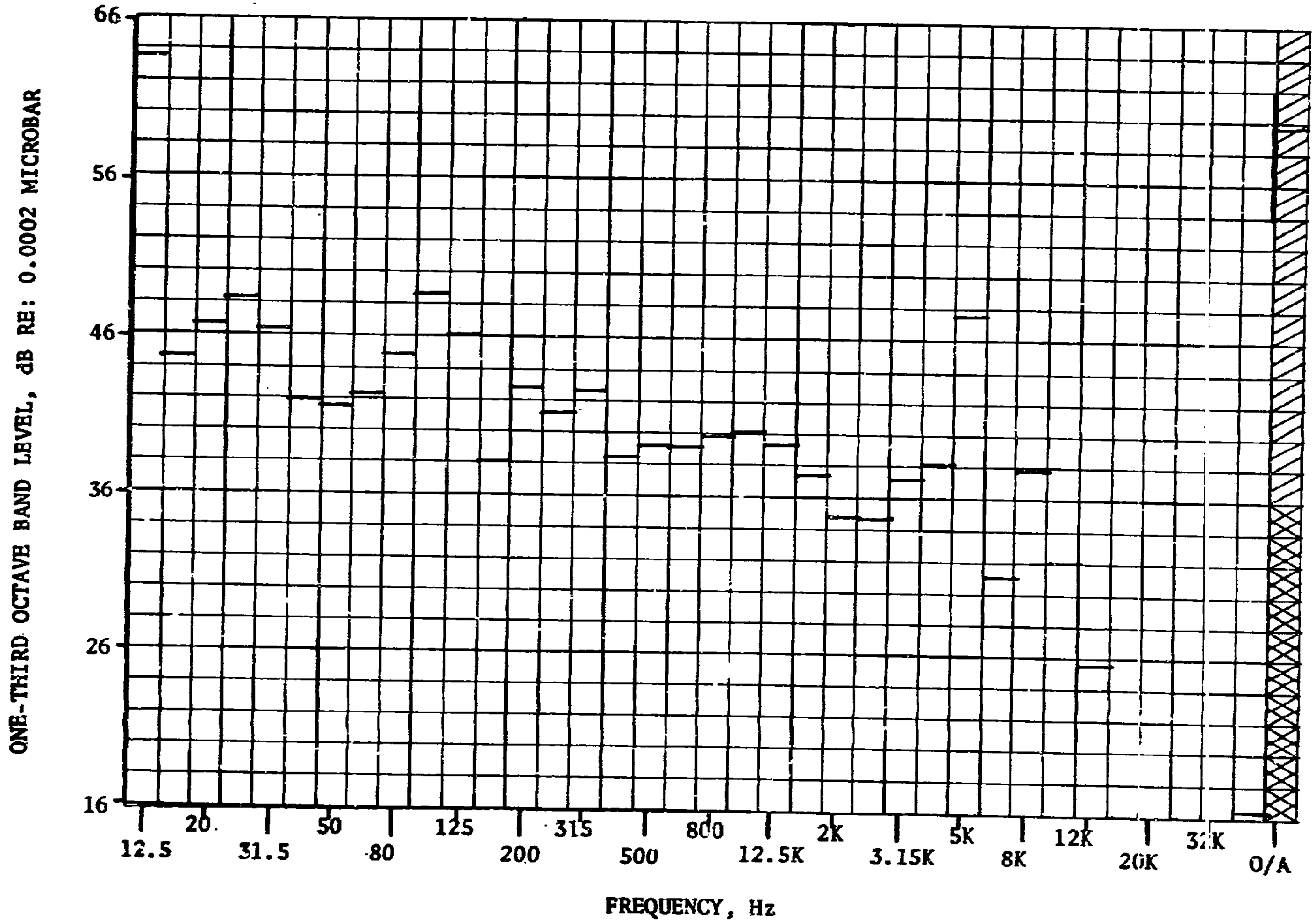

FIG 43. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 105 FOOT ALTITUDE AND AT A VELOCITY OF 88 FT/SEC

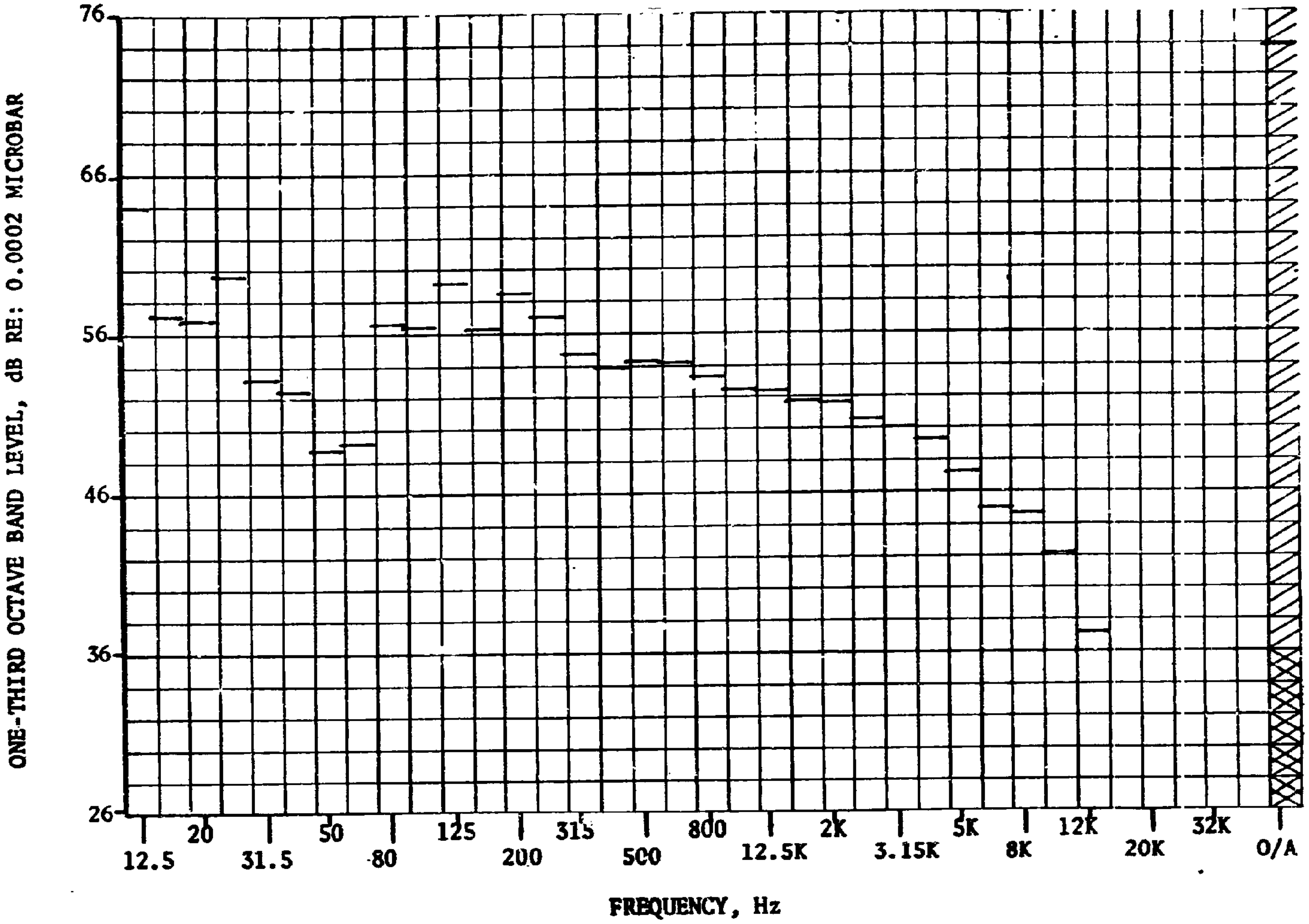

FIG 44. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 45 FOOT ALTITUDE AND AT A VELOCITY OF 120 FT/SEC

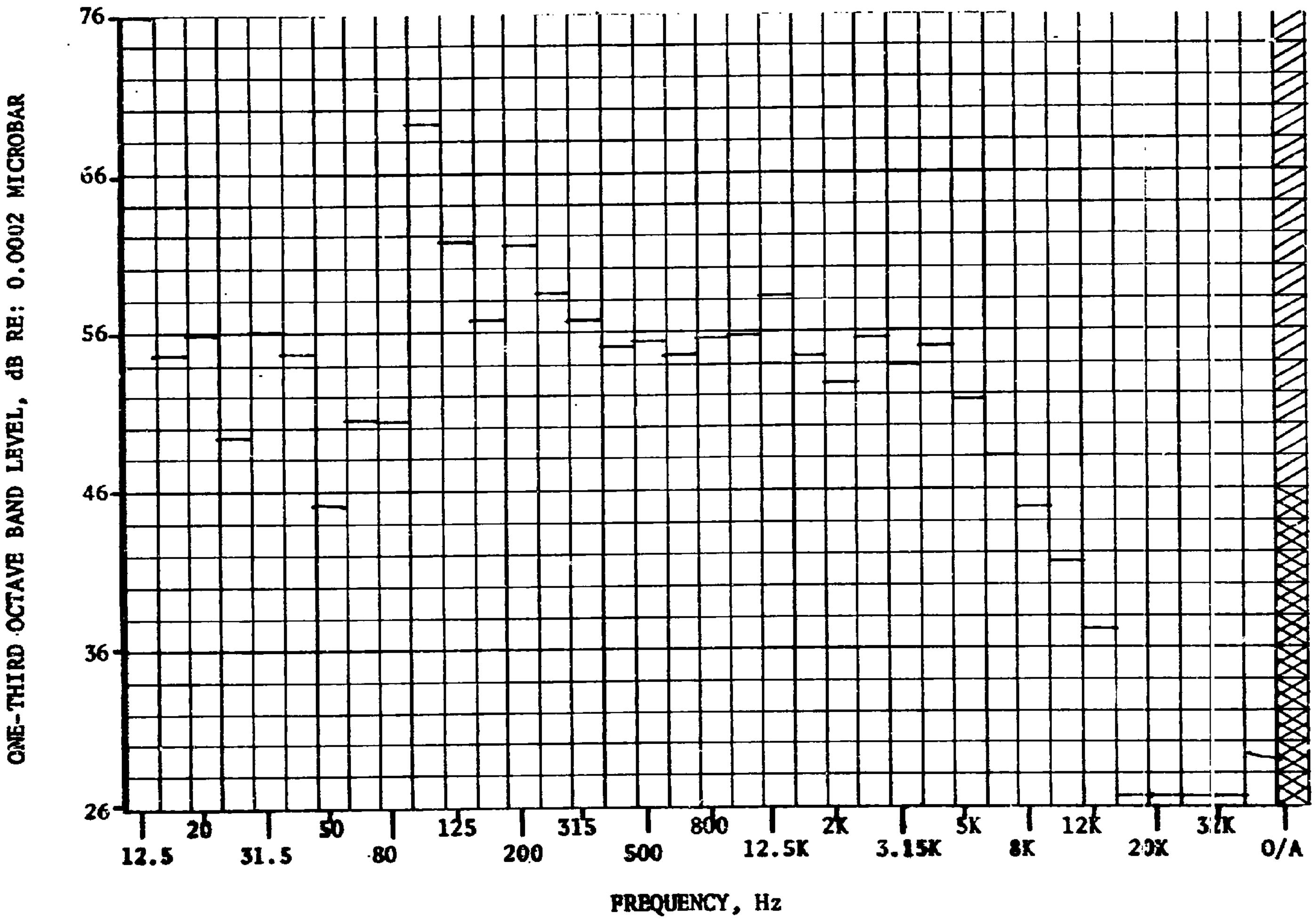

FIG 45. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 48 FOOT ALTITUDE AND AT A VELOCITY OF 133 FT/SEC

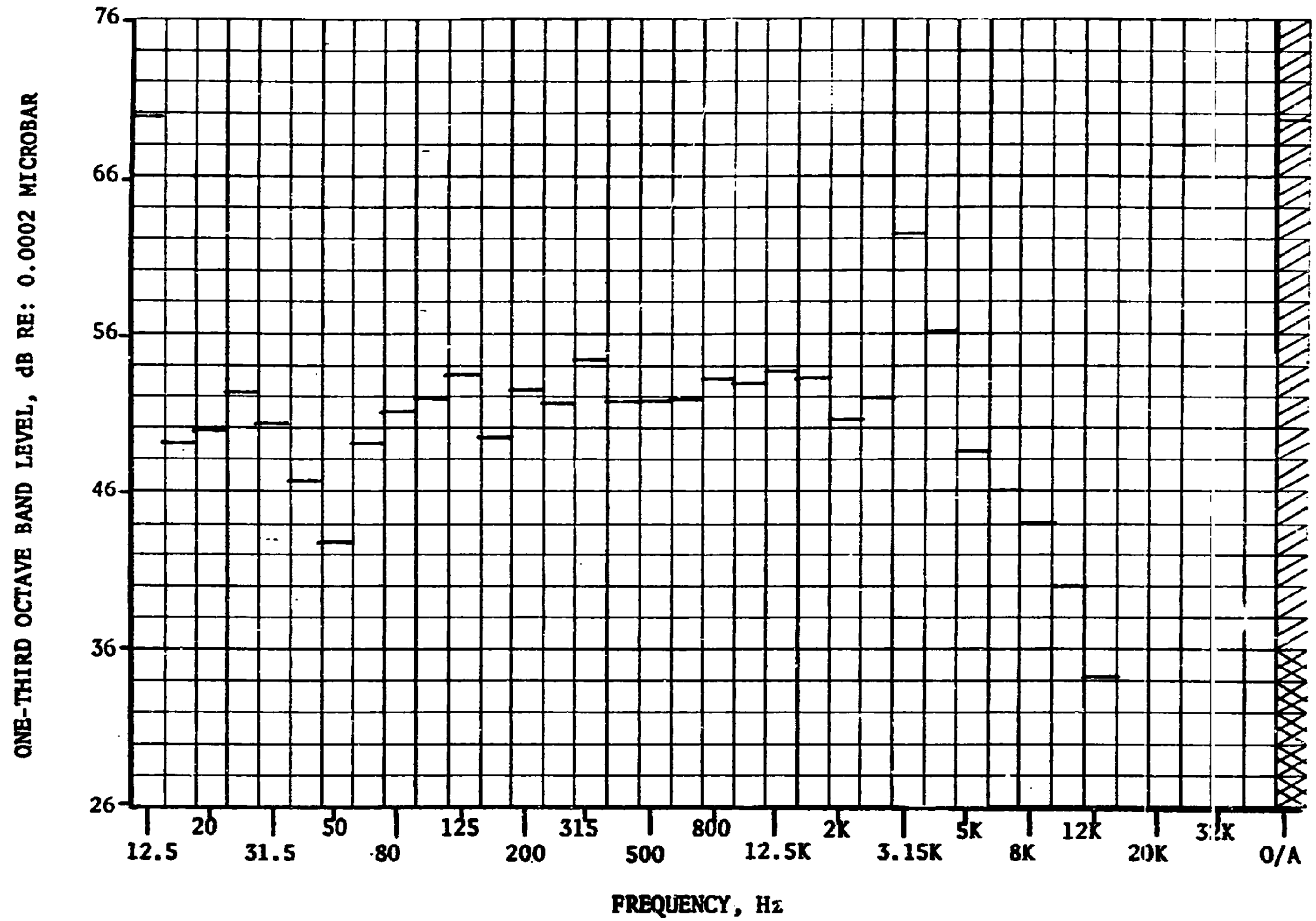

FIG 46. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-32 FLYBY AT 81 FOOT ALTITUDE AND AT A VELOCITY OF 147 FT/SEC

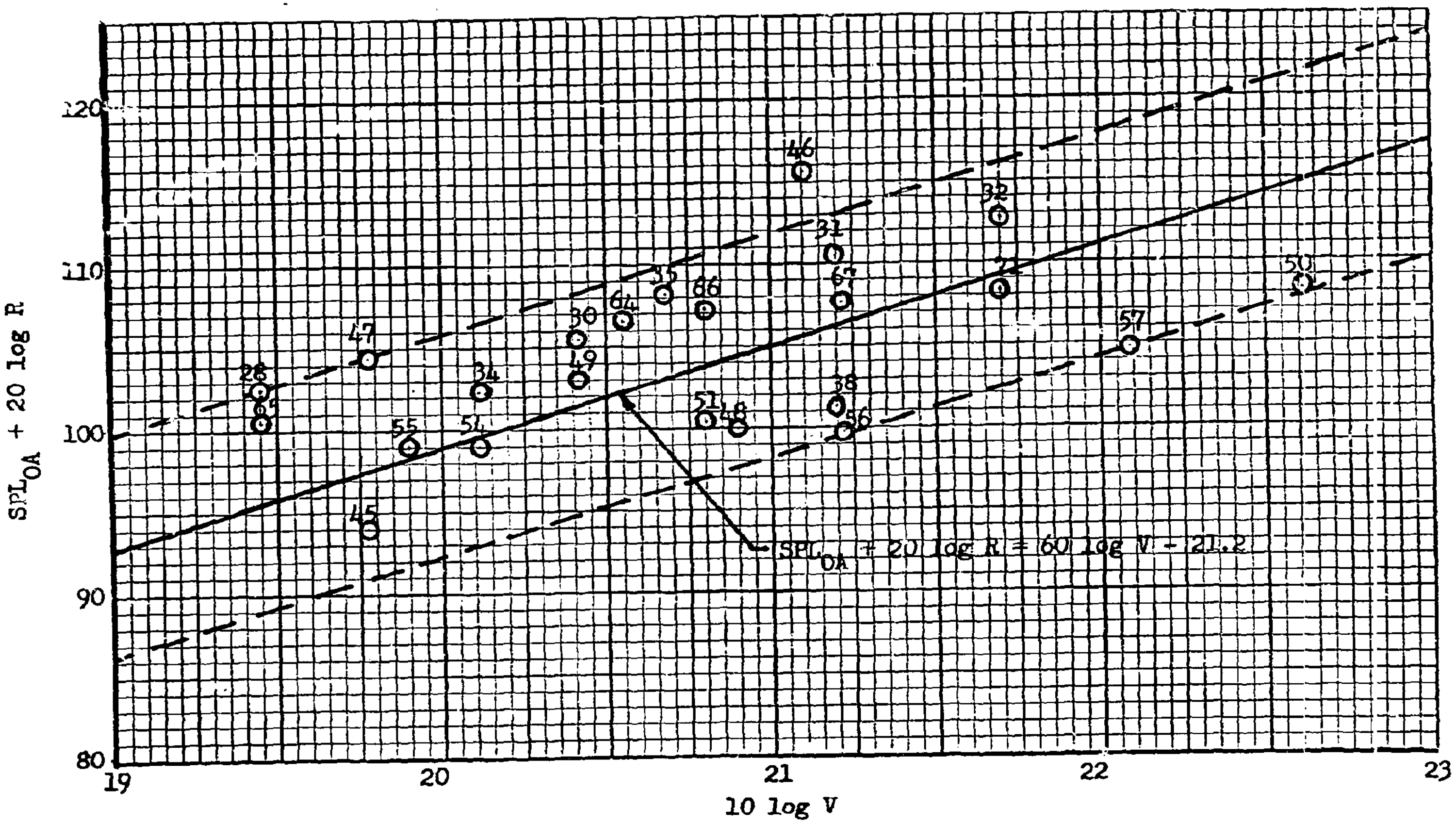

FIG 47. RESULTS FROM SCHWEIZER 2-32 FLYBY NOISE MEASUREMENTS (MICROPHONE 1)

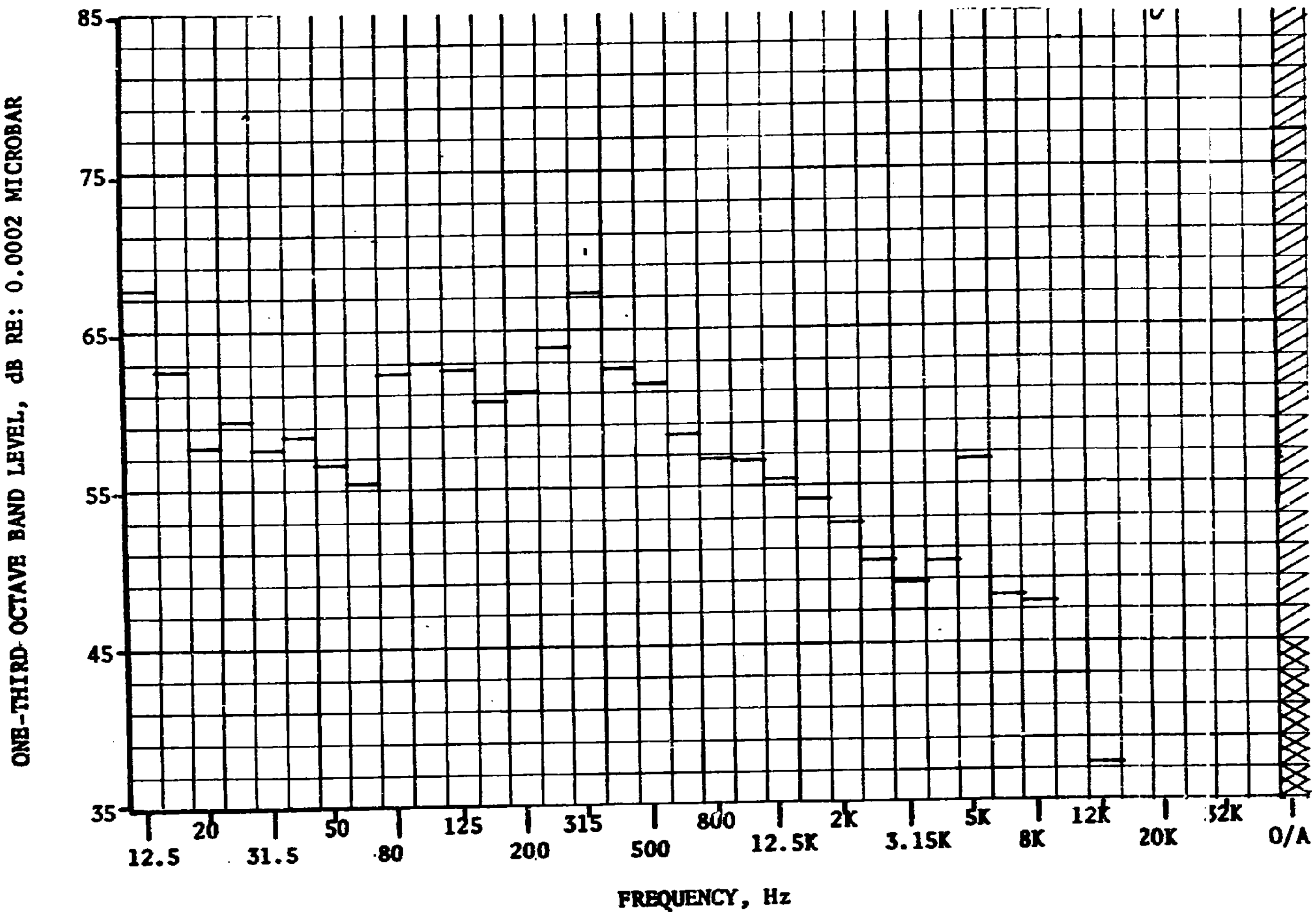

FIG 48. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 115 FOOT ALTITUDE AND AT A VELOCITY OF 77.7 FT/SEC

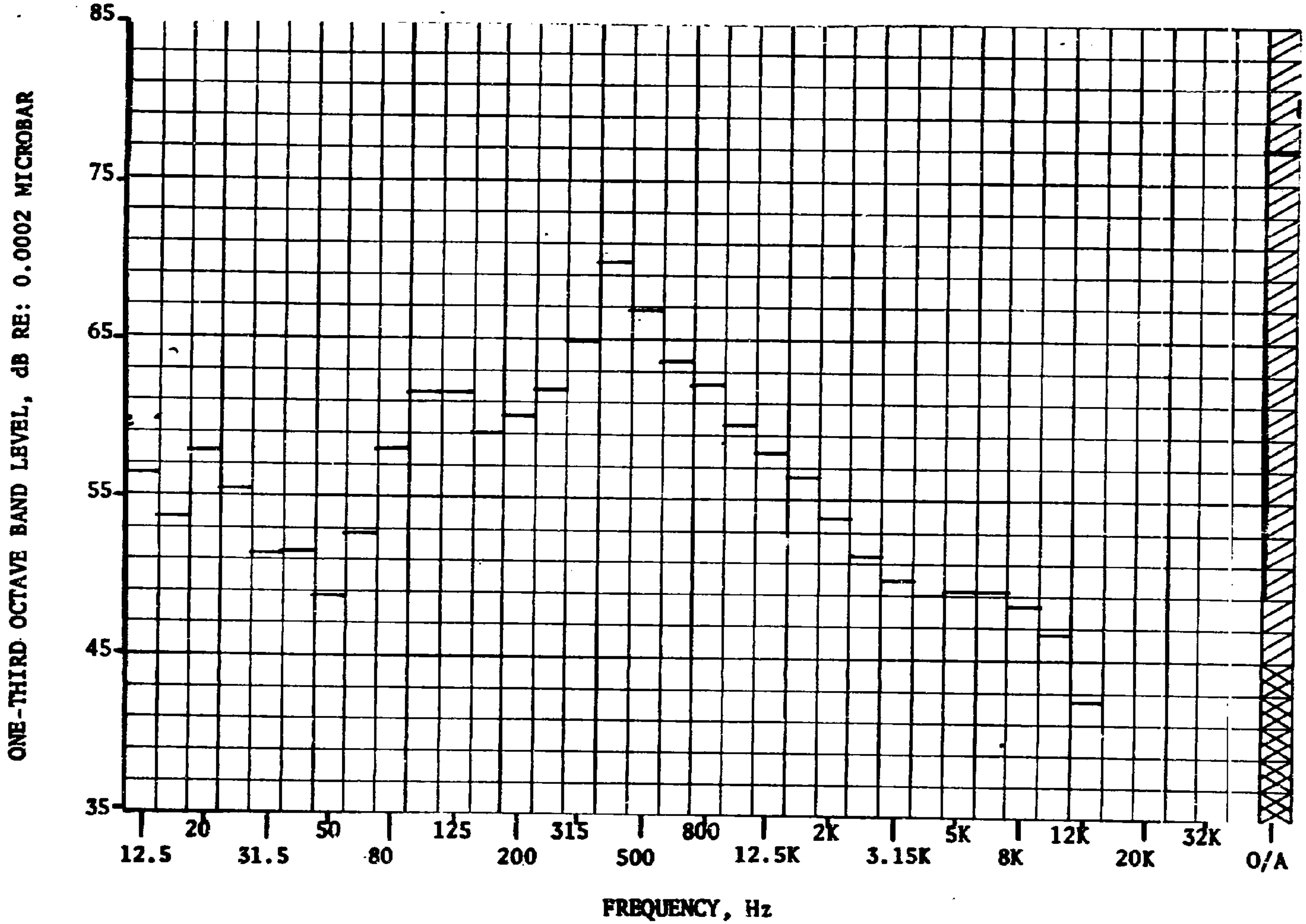

FIG 49. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 115 FOOT ALTITUDE AND AT A VELOCITY OF 110 FT/SEC

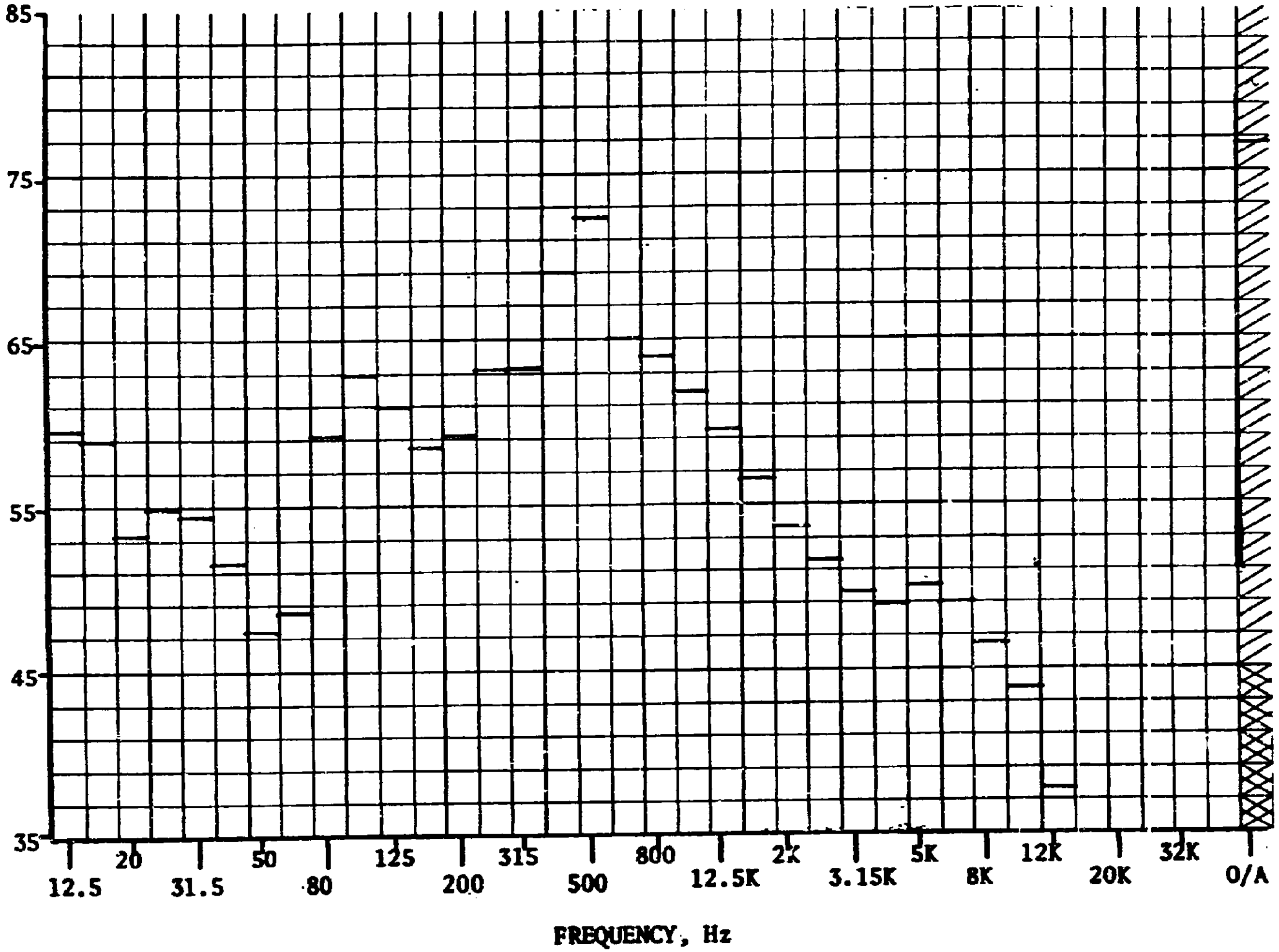

FIG 50. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 115 FOOT ALTITUDE AND AT A VELOCITY OF 129 FT/SEC

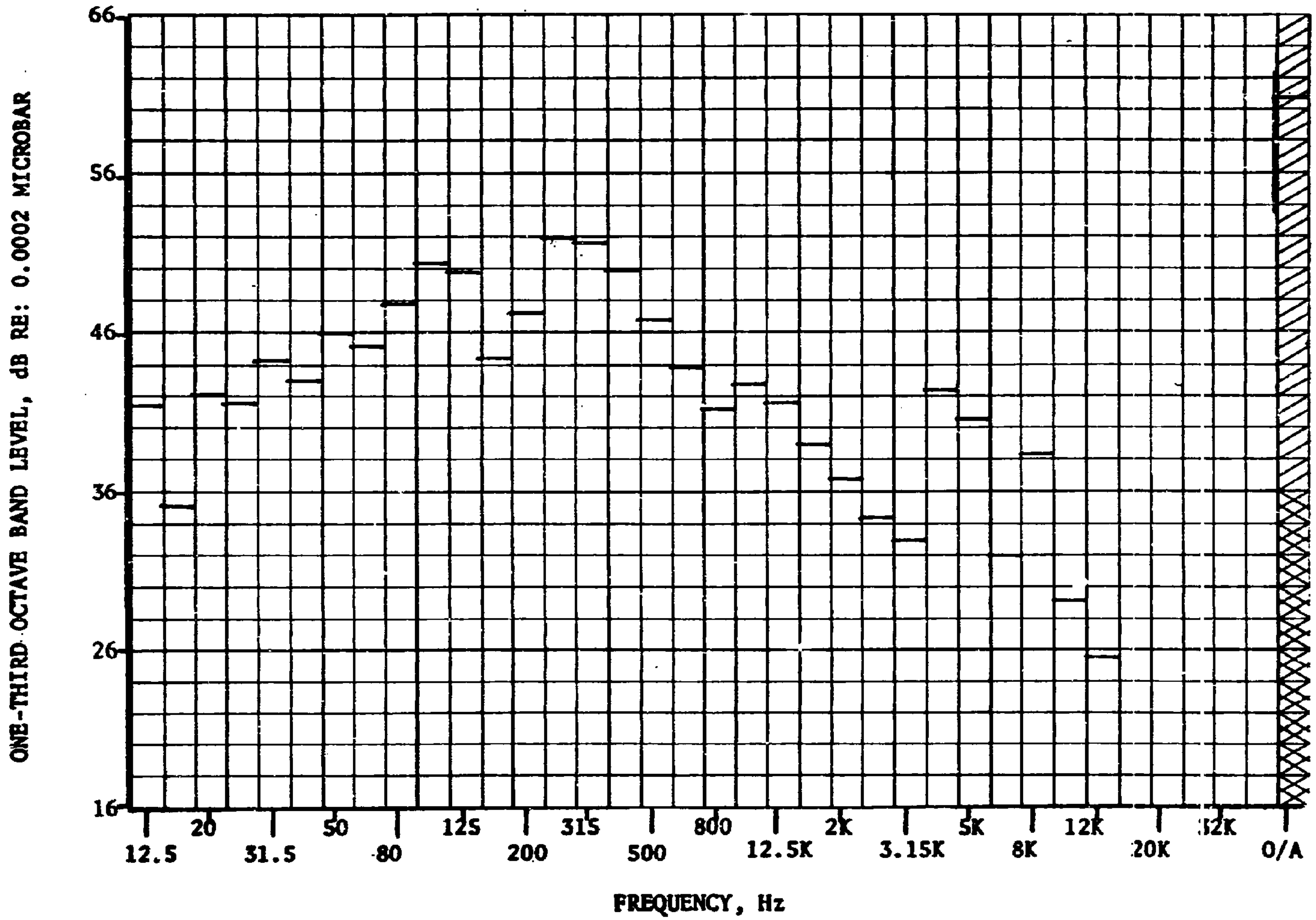

FIG 51. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 105 FOOT ALTITUDE AND AT A VELOCITY OF 73 FT/SEC

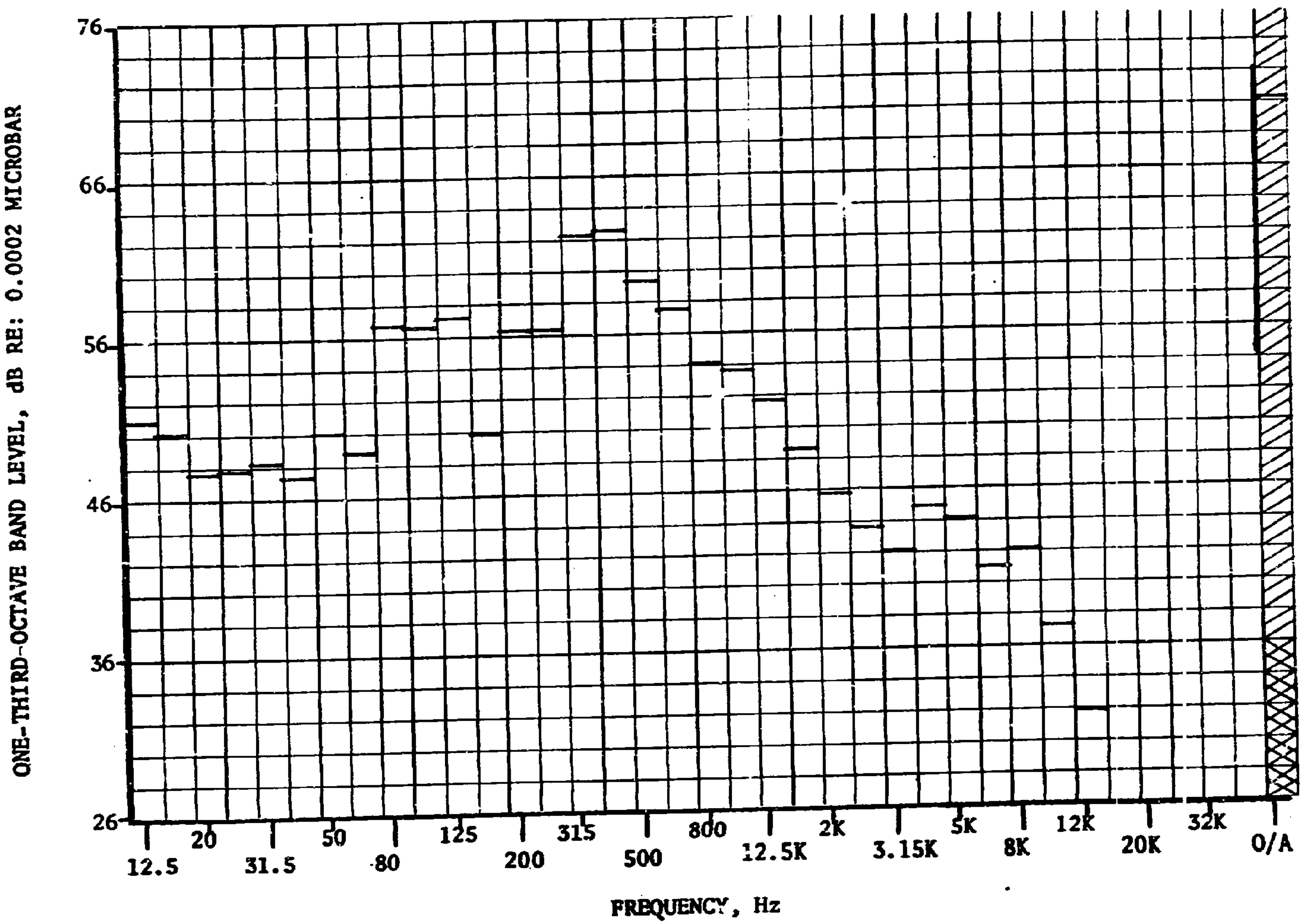

FIG 52. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 95 FOOT ALTITUDE AND AT A VELOCITY OF 99.7 FT/SEC

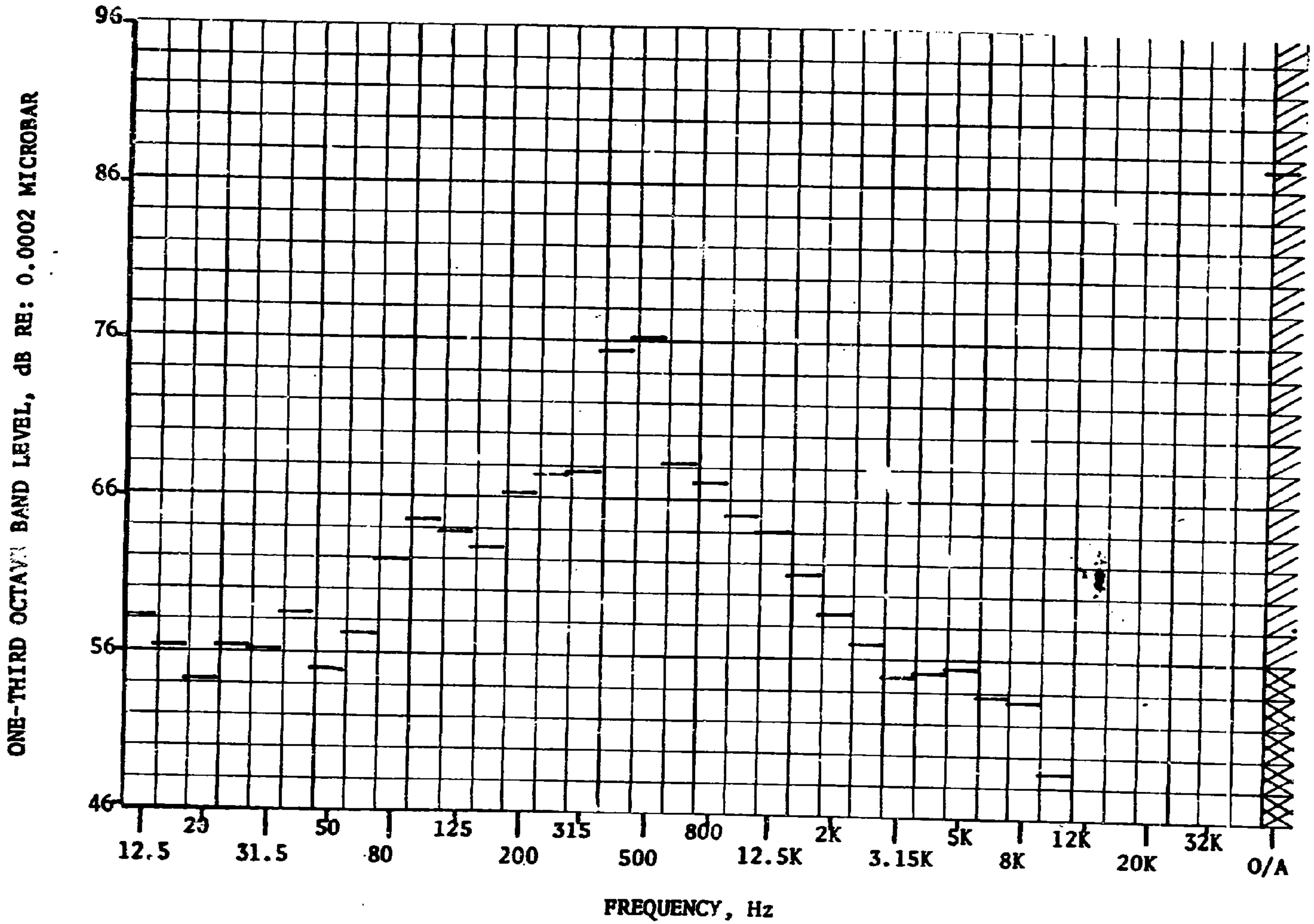

FIG 53. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 30 FOOT ALTITUDE AND AT A VELOCITY OF 129 FT/SEC

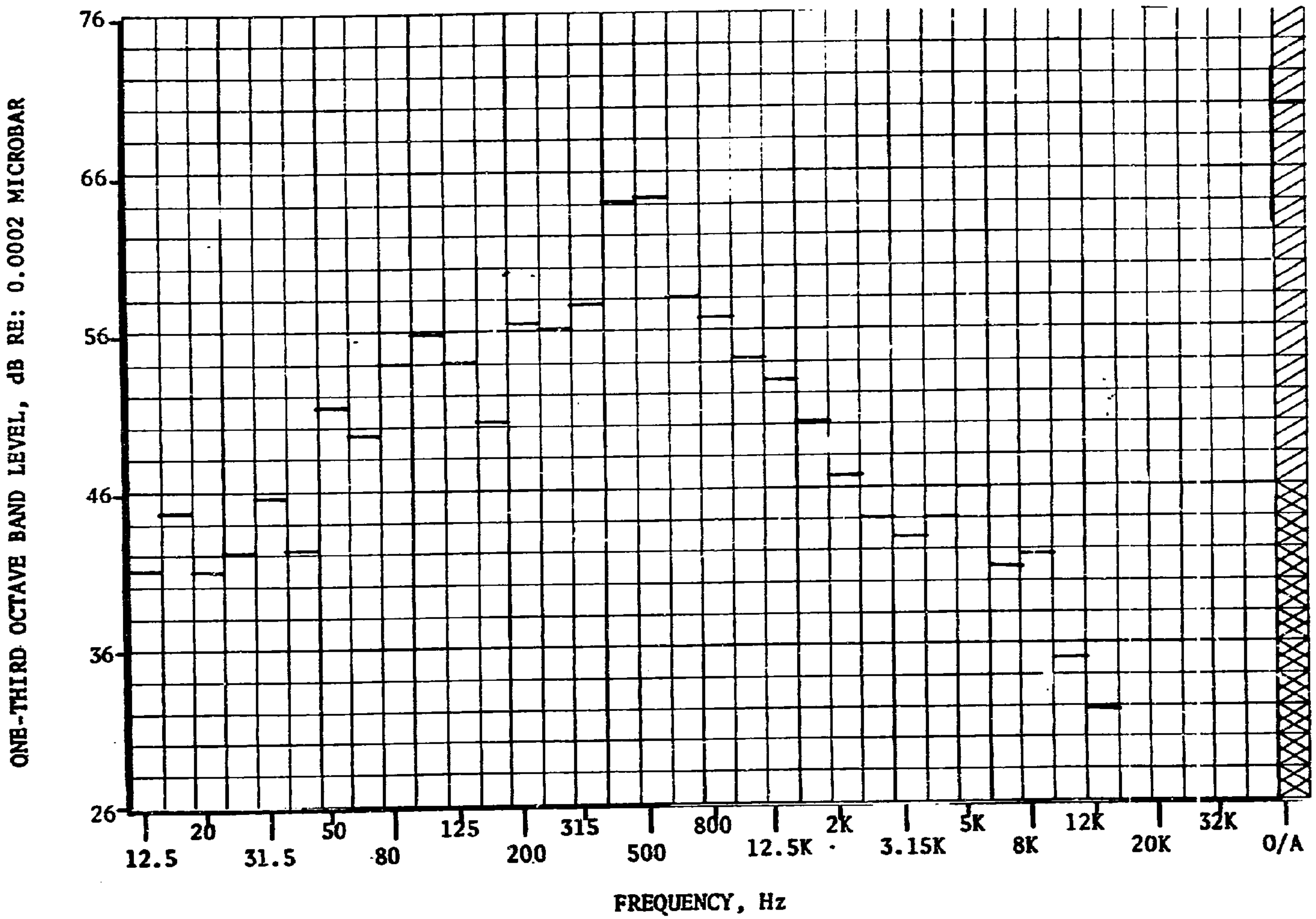

FIG 54. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 105 FOOT ALTITUDE AND AT A VELOCITY OF 117 FT/SEC

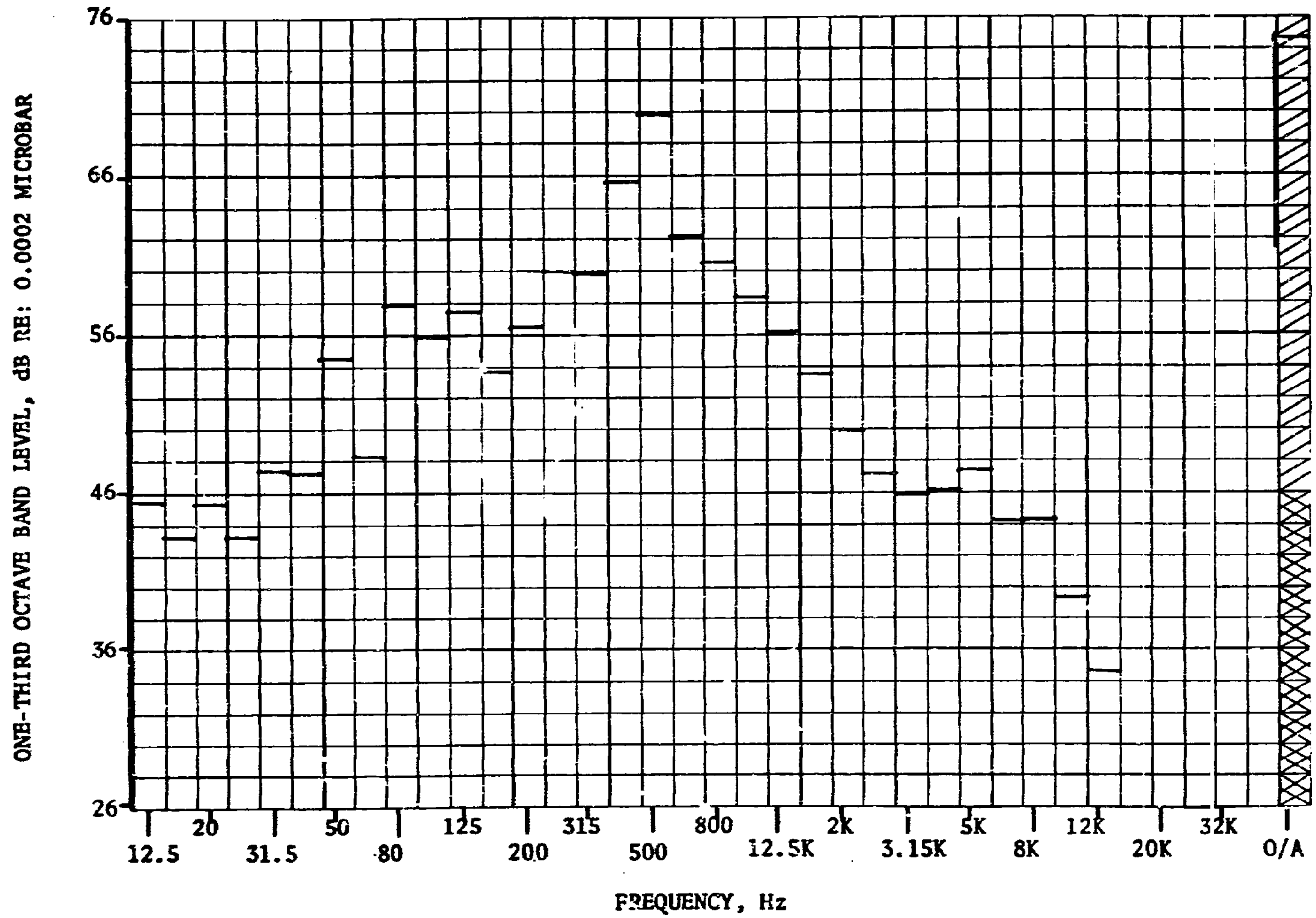

FIG 55. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33

FLYBY AT 110 FOOT ALTITUDE AND AT A VELOCITY OF 132 FT/SEC

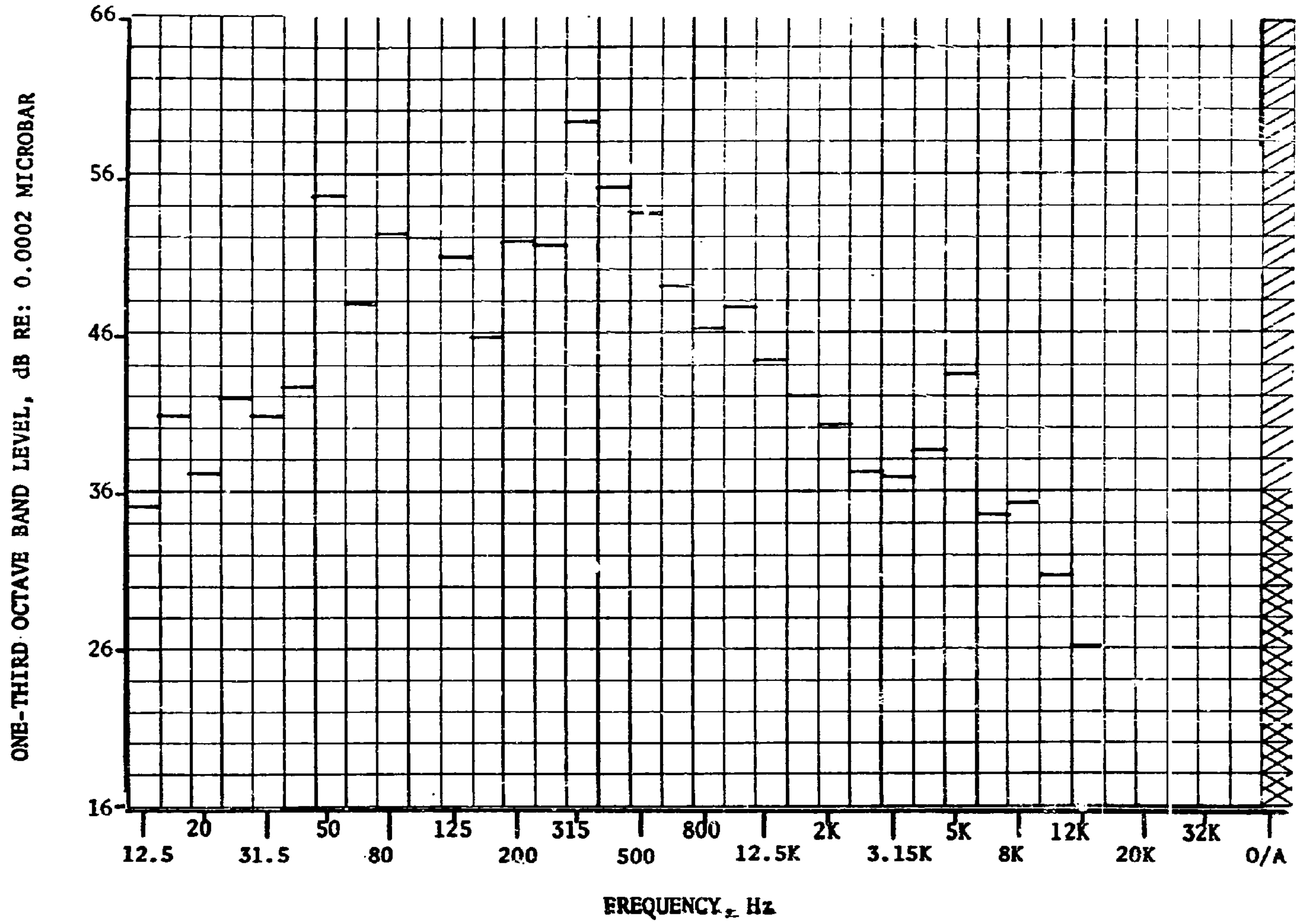

FIG 56. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 105 FOOT ALTITUDE AND AT A VELOCITY OF 88 FT/SEC

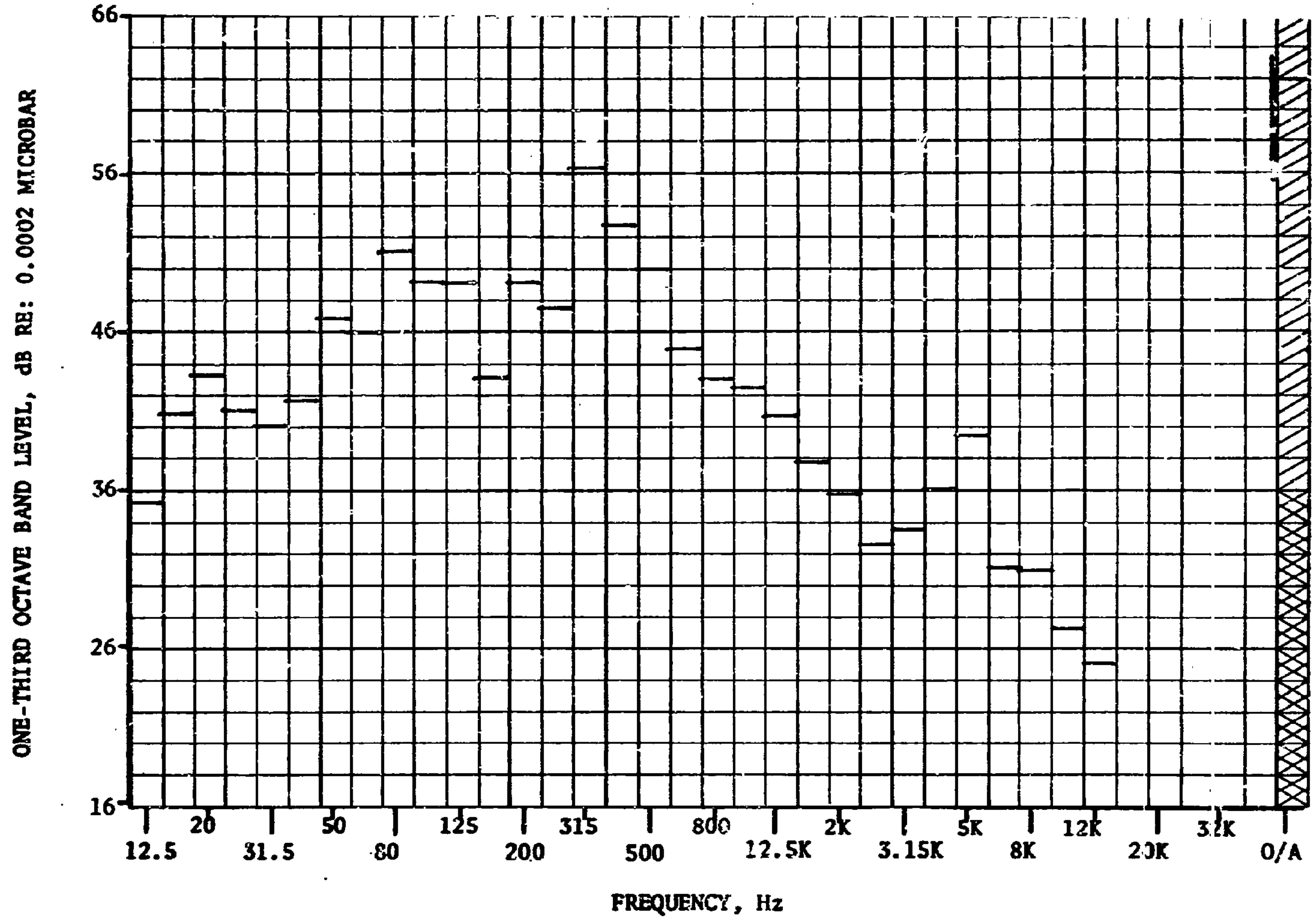

FIG 57. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 120 FOOT ALTITUDE AND AT A VELOCITY OF 88 FT/SEC

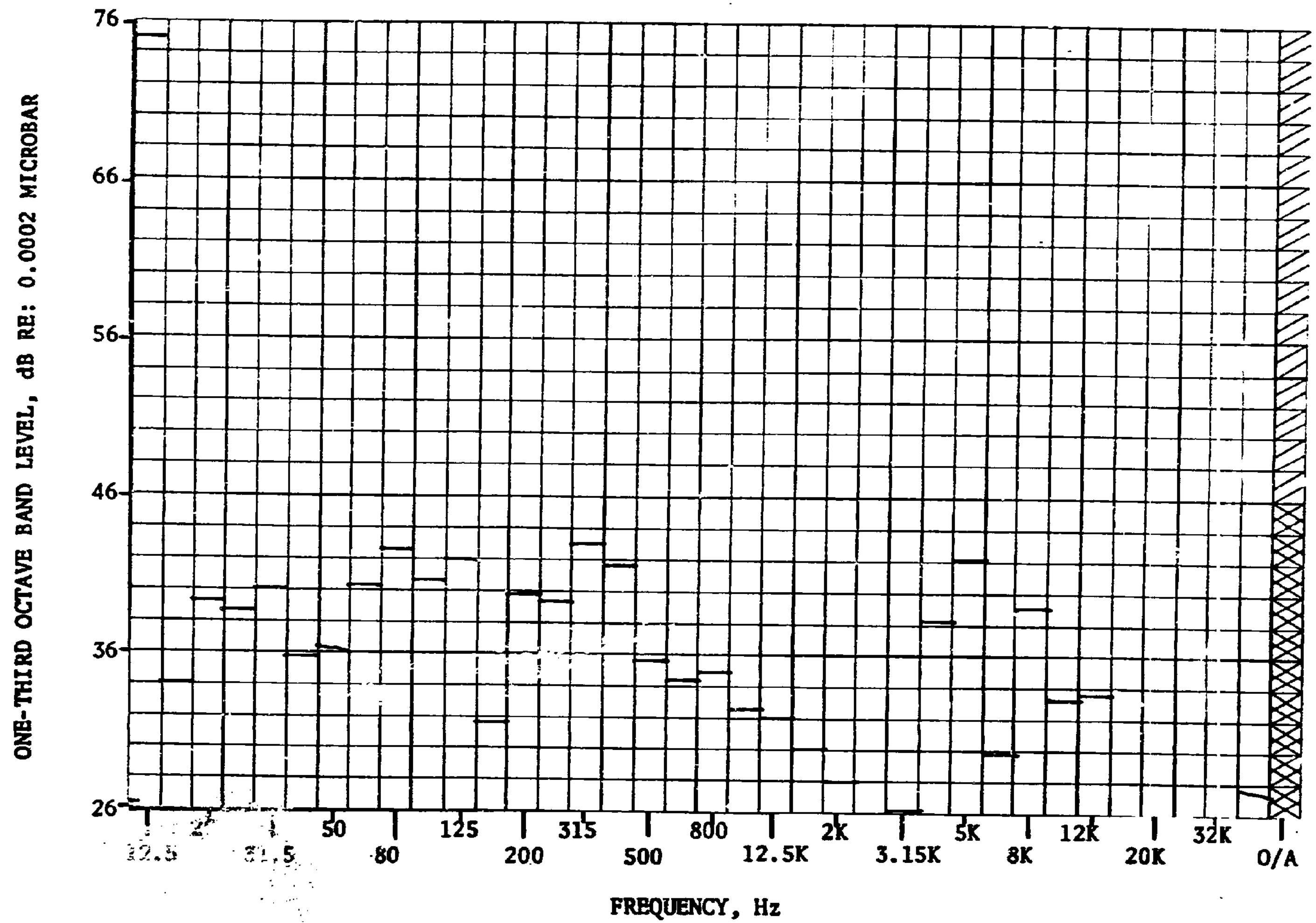

FIG 58. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-3? FLYBY AT 178 FOOT ALTITUDE AND AT A VELOCITY OF 77.7 FT/SEC

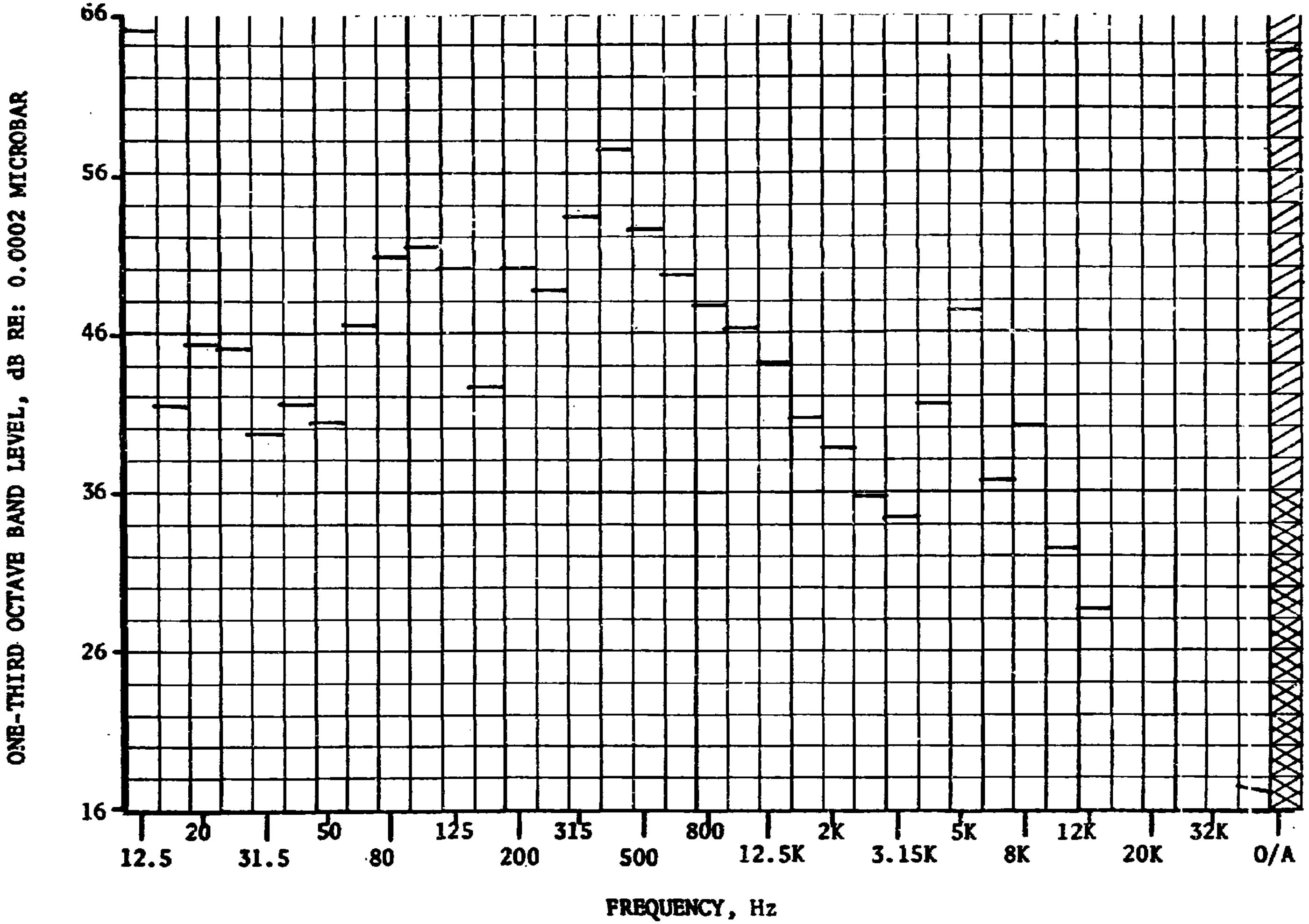

FIG 59. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 148 FOOT ALTITUDE AND AT A VELOCITY OF 110 FT/SEC

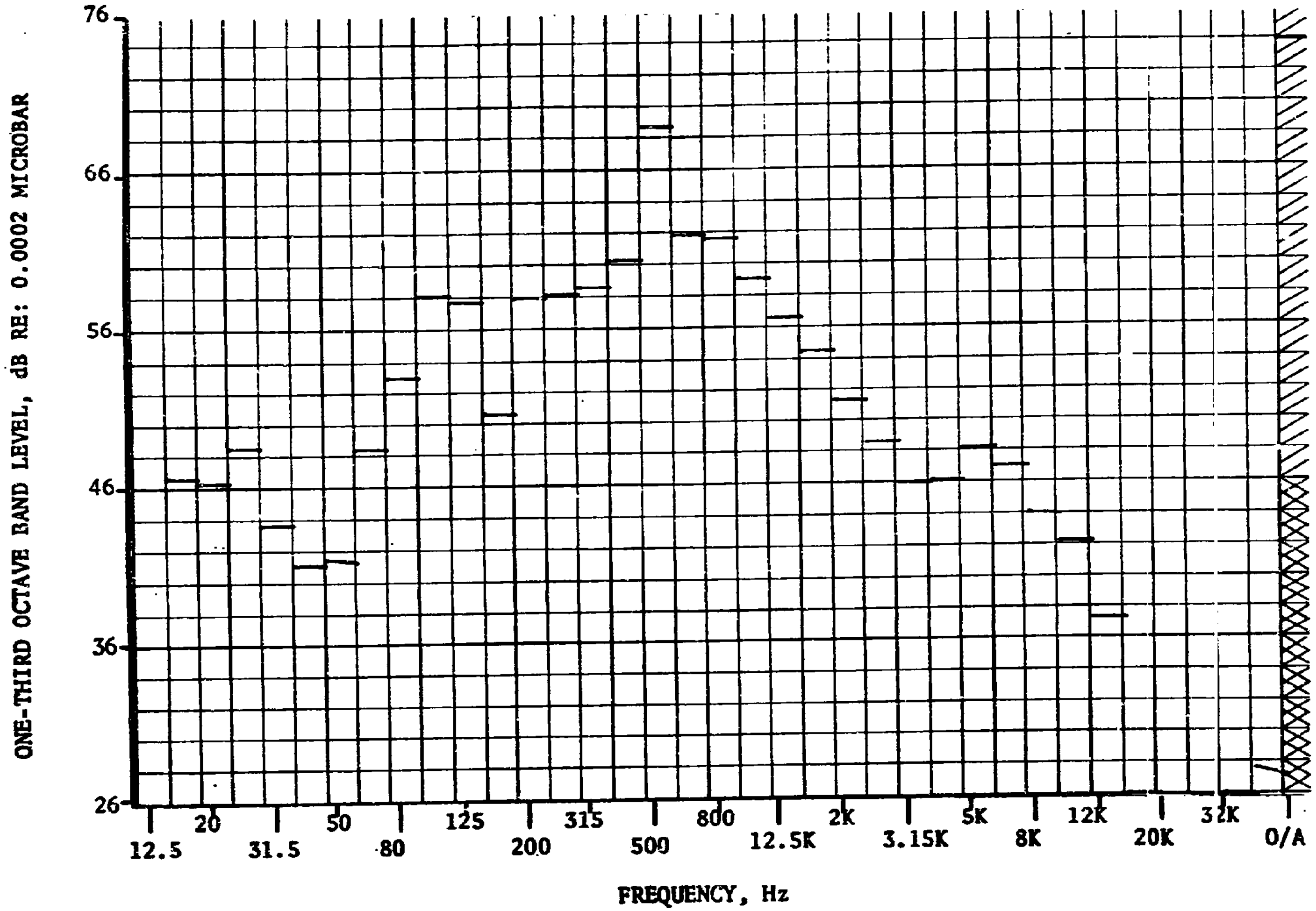

FIG 60. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE SCHWEIZER 2-33 FLYBY AT 80 FOOT ALTITUDE AND AT A VELOCITY OF 142 FT/SEC

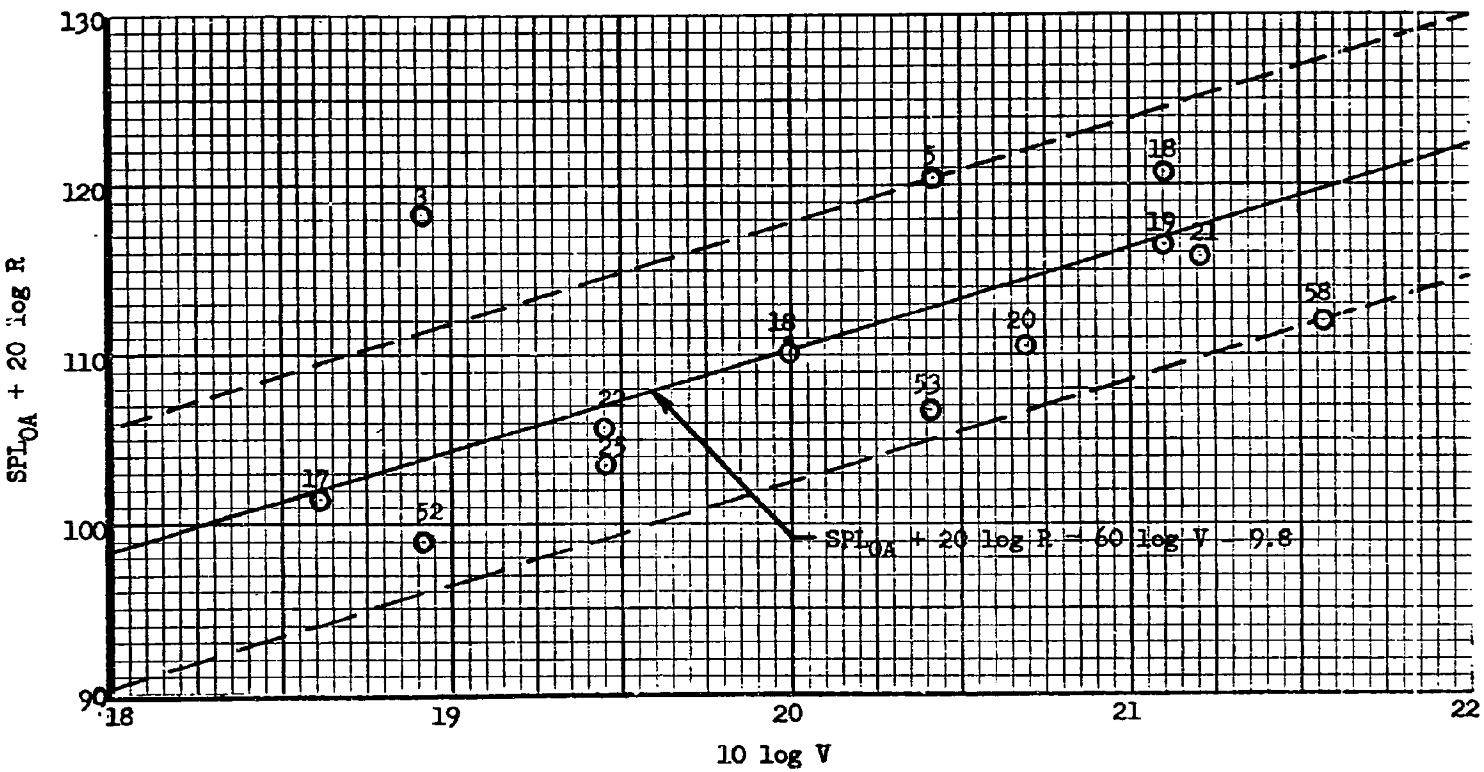

FIG 61. RESULTS FROM SCHWEIZER 2-33 FLYBY NOISE MEASUREMENTS (MICROPHONE 1)

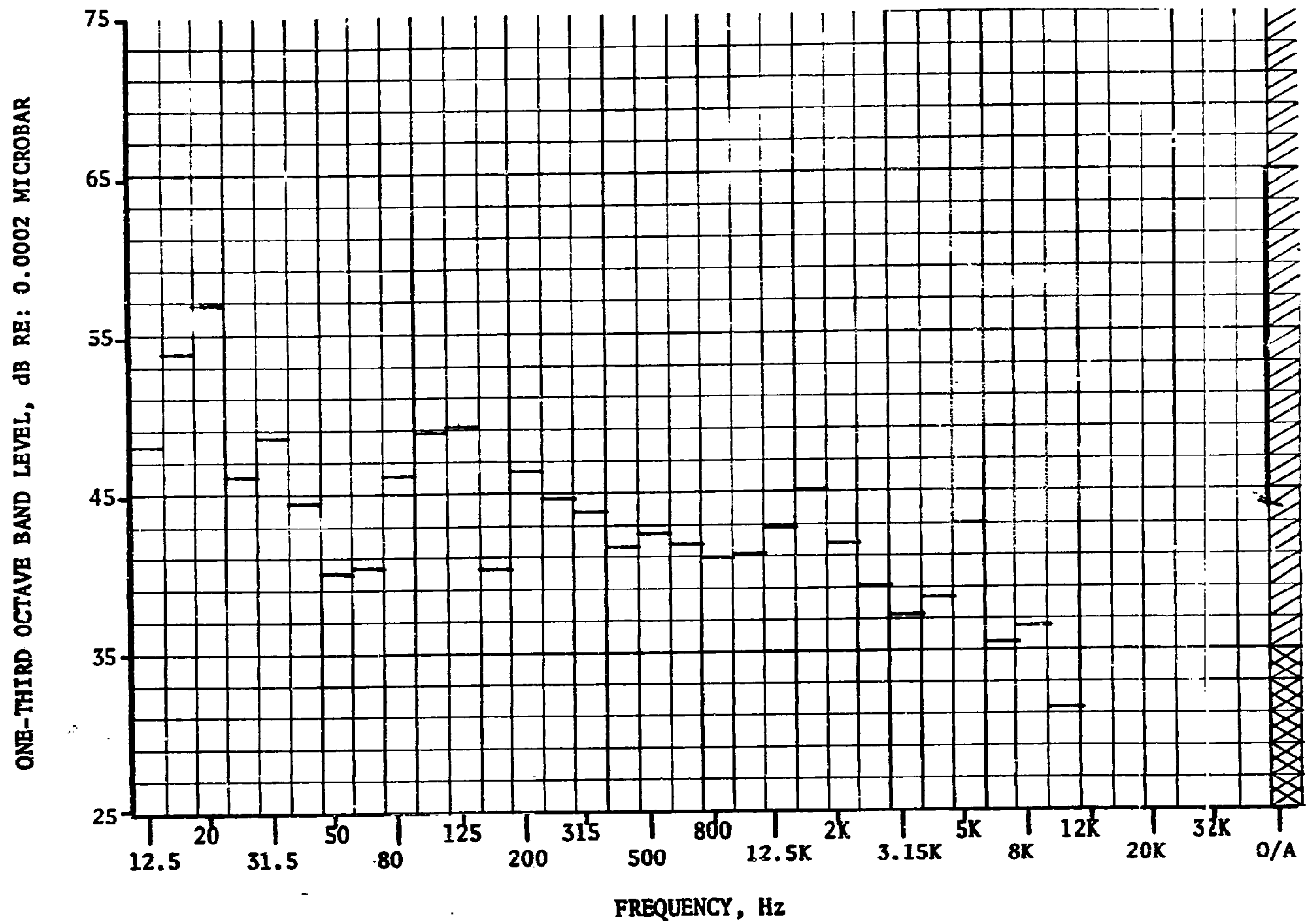

FIG 62. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 115 FOOT ALTITUDE AND AT A VELOCITY OF 139 FT/SEC

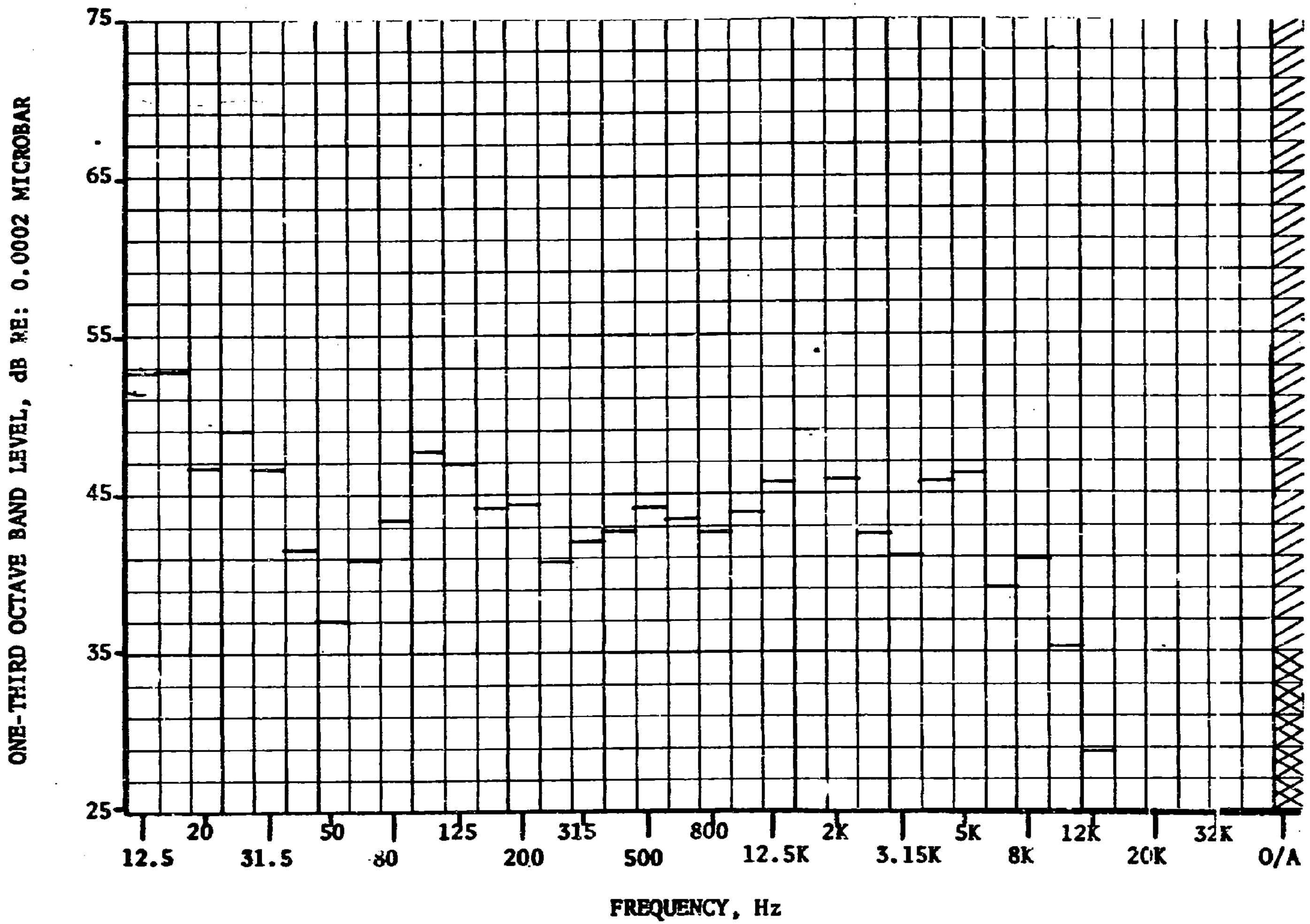

FIG 63. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 95 FOOT ALTITUDE AND AT A VELOCITY OF 144 FT/SEC

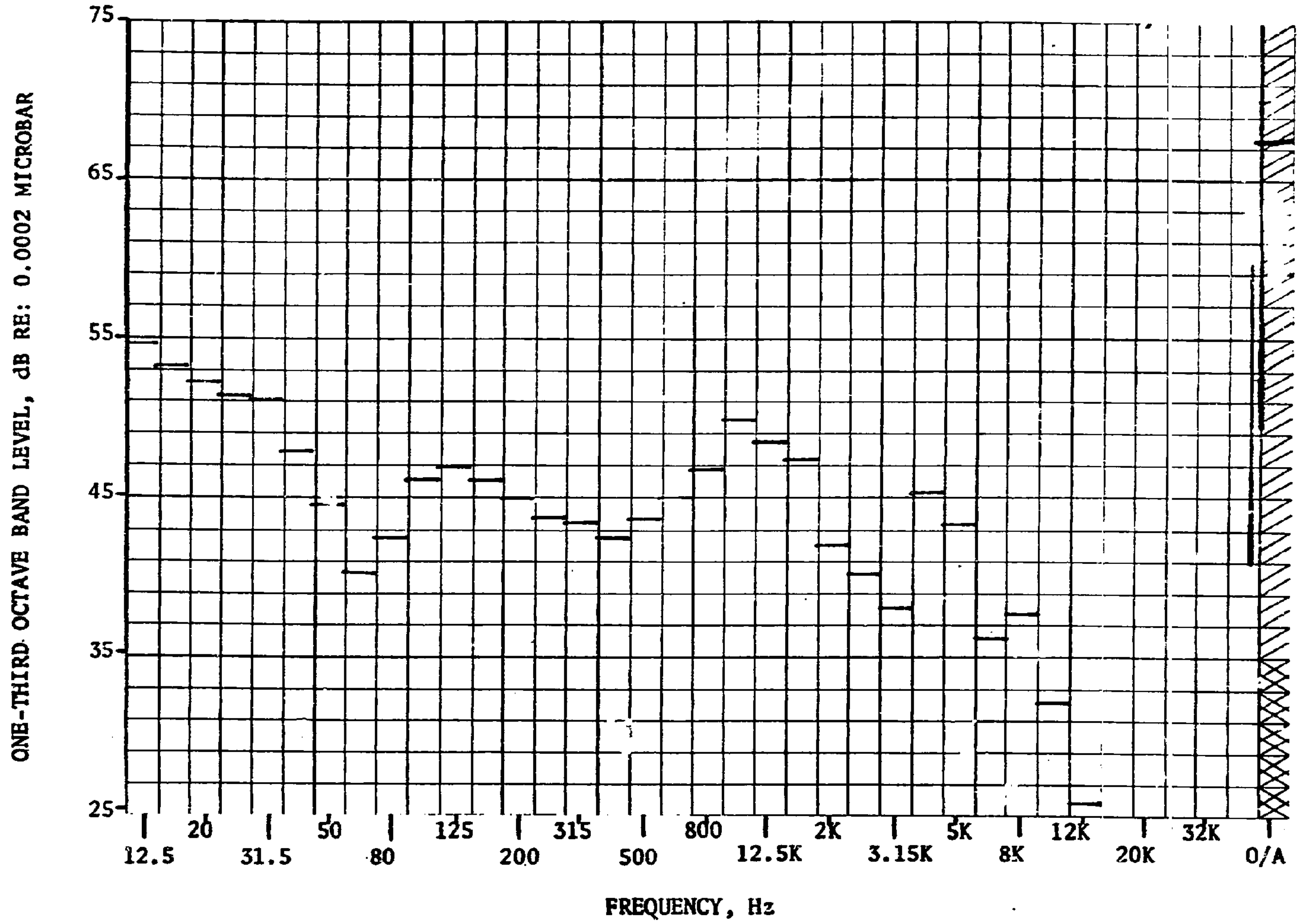

FIG 64. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 55 FOOT ALTITUDE AND AT A VELOCITY OF 101 FT/SEC

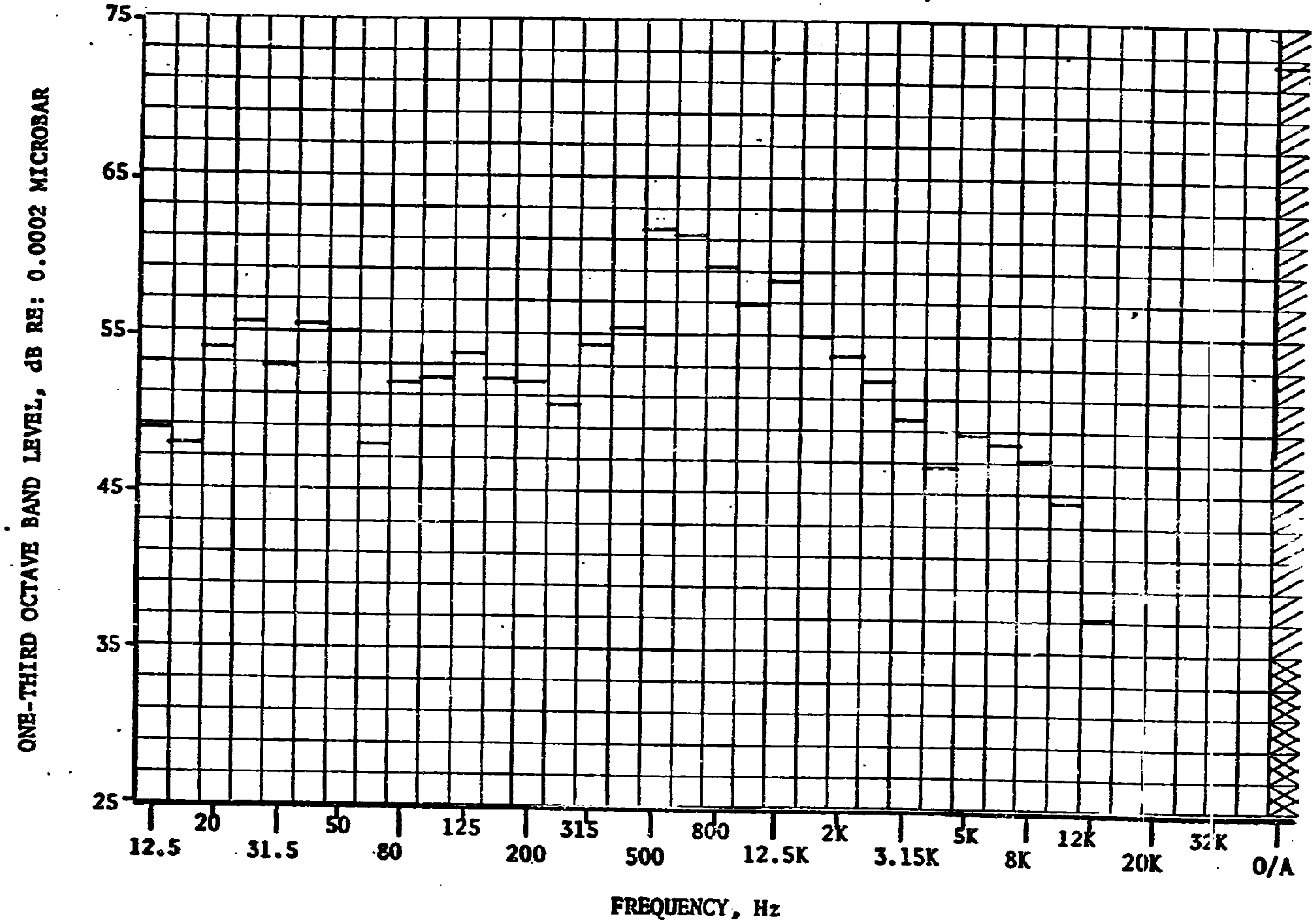

FIG 65. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 95 FOOT ALTITUDE AND AT A VELOCITY OF 85 FT/SEC

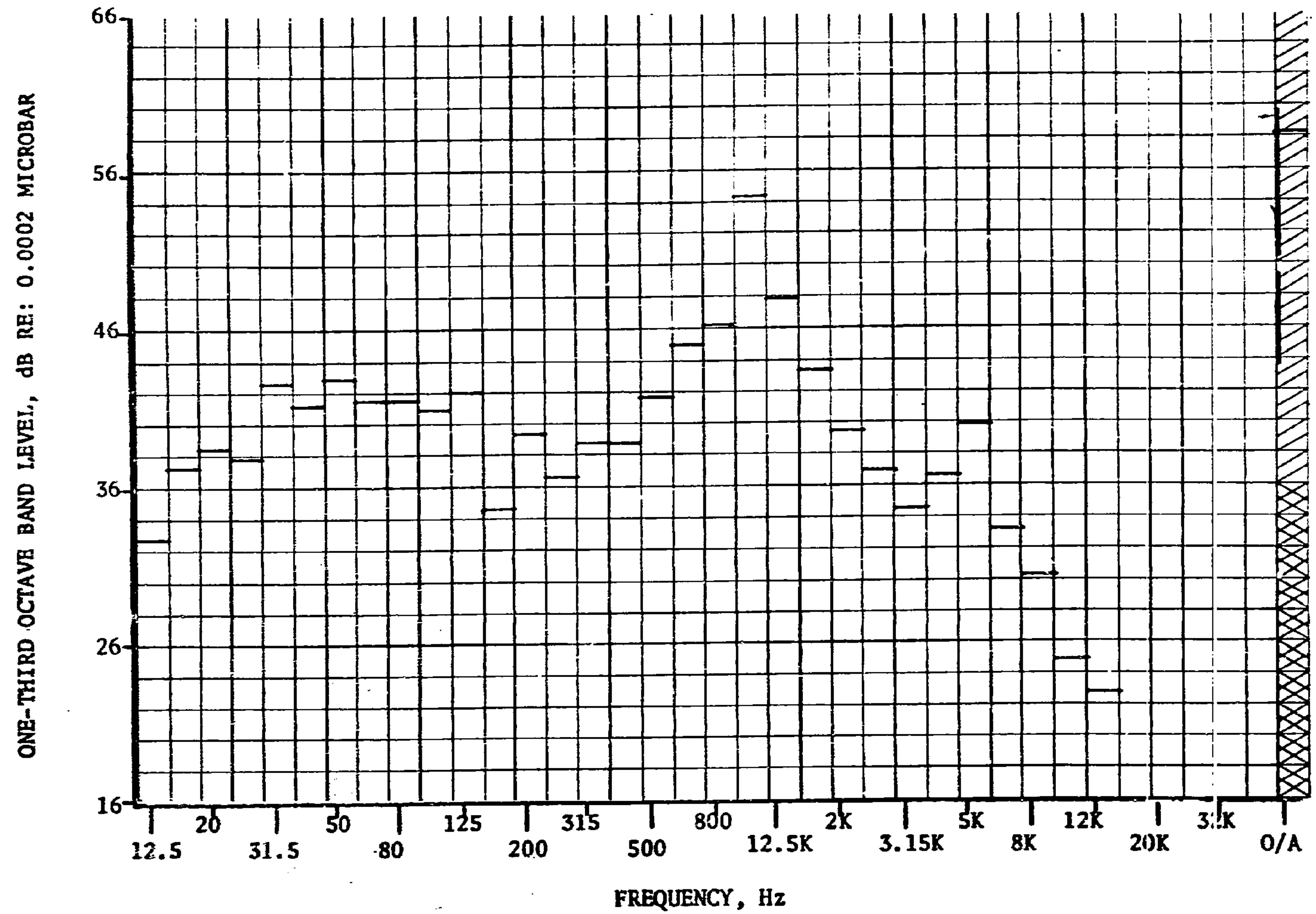

FIG 66. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 90 FOOT ALTITUDE AND AT A VELOCITY OF 104 FT/SEC

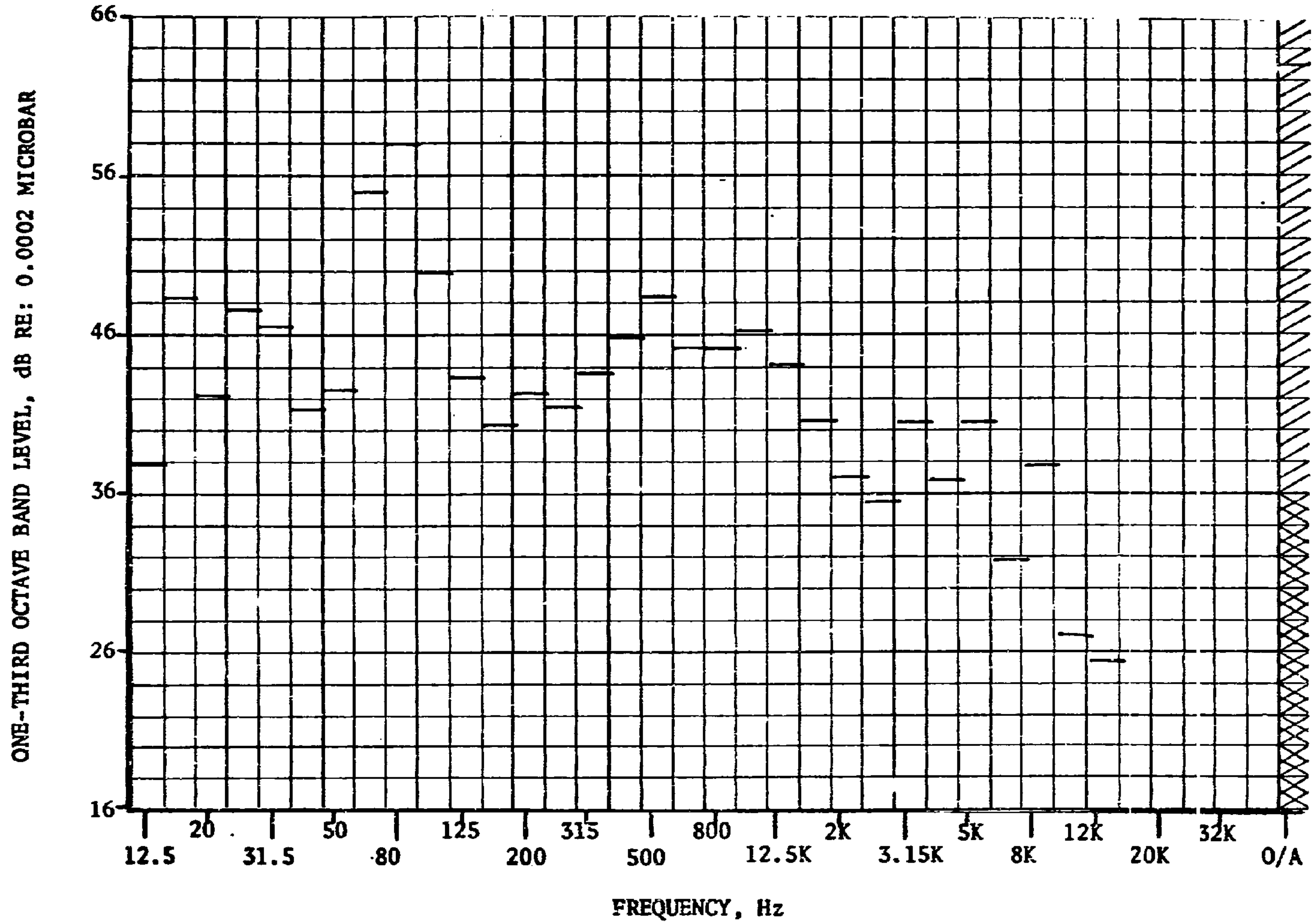

FIG 67. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 85 FOOT ALTITUDE AND AT A VELOCITY OF 85 FT/SEC

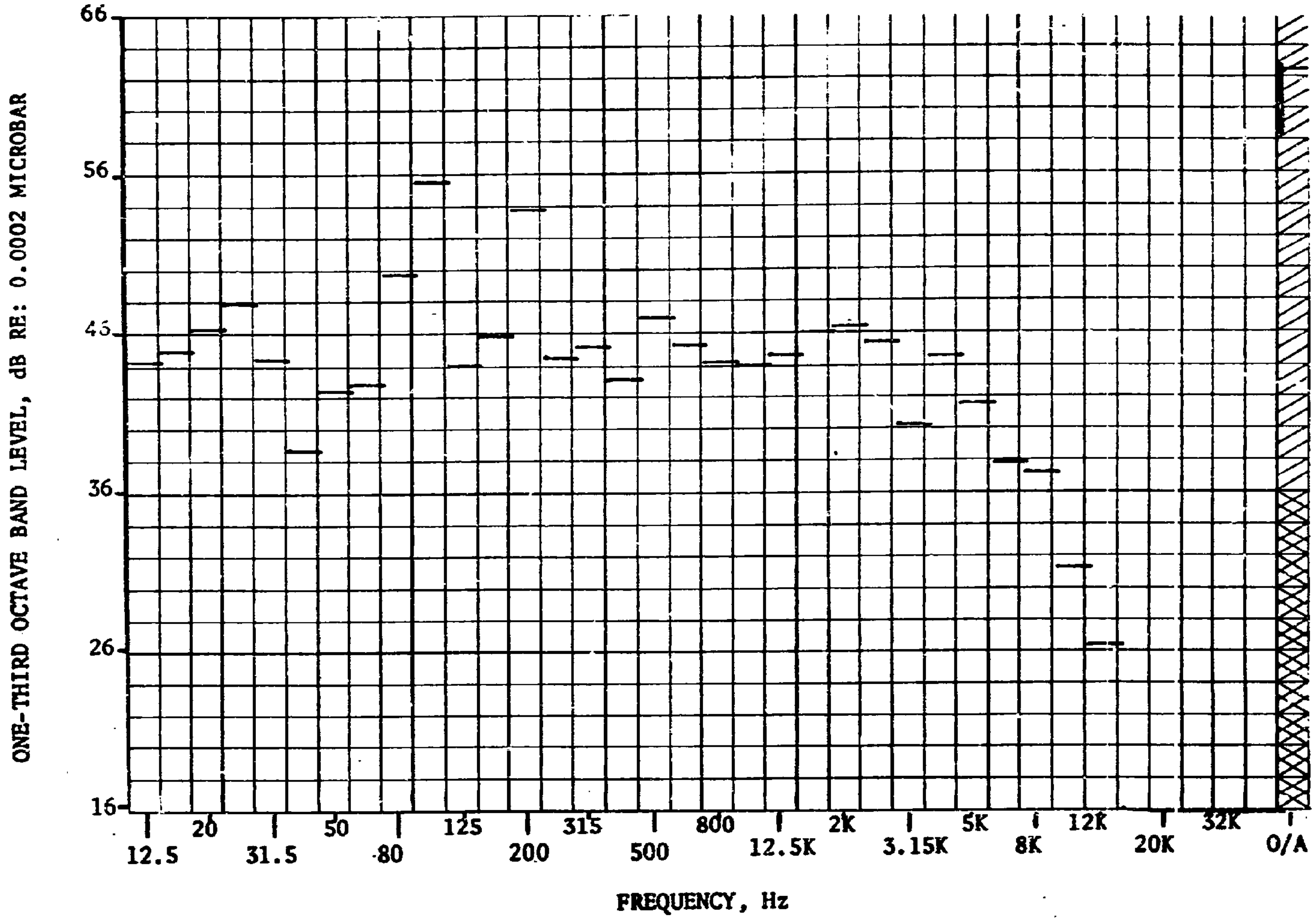

FIG 68. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 85 FOOT ALTITUDE AND AT A VELOCITY OF 142 FT/SEC

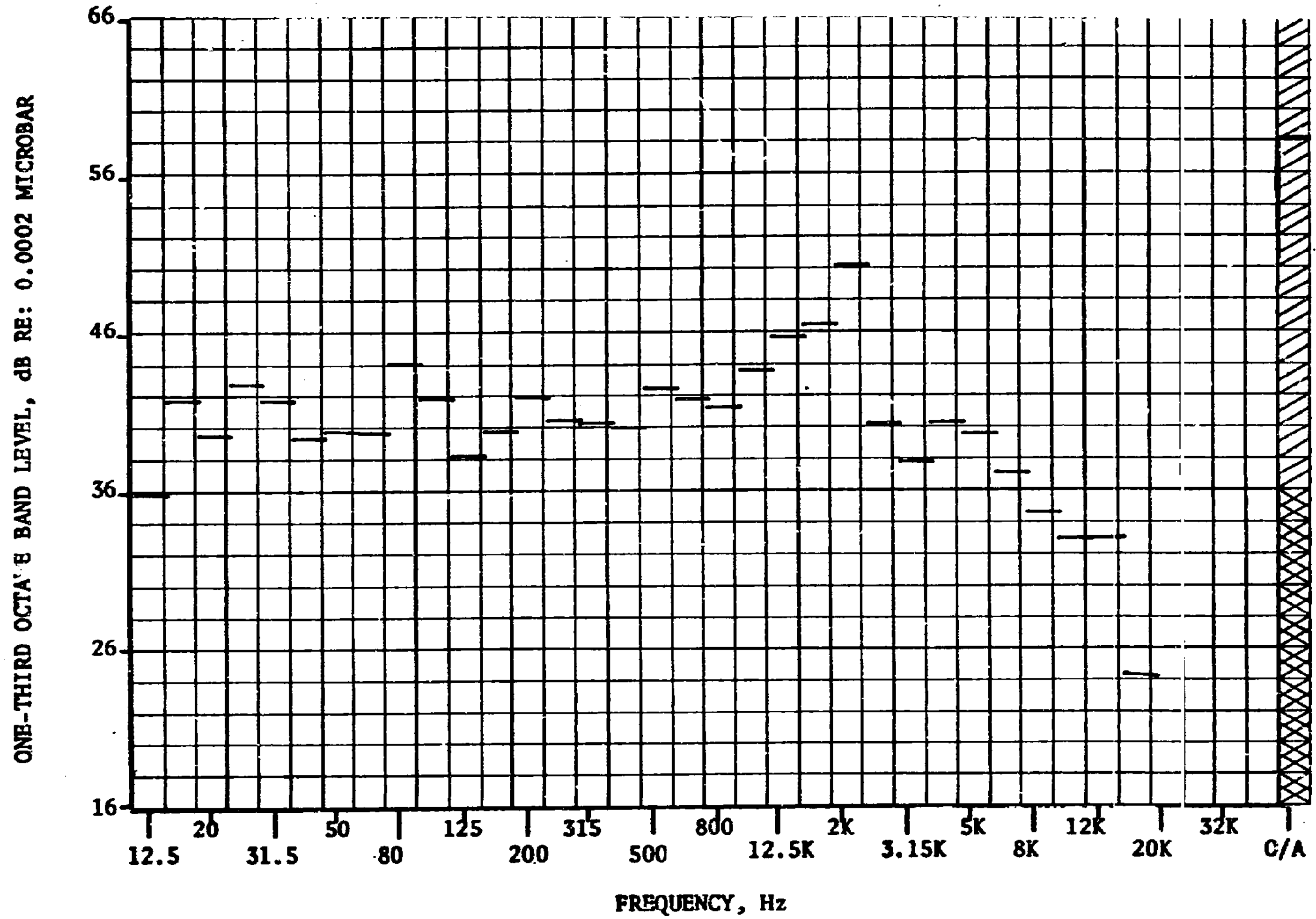

FIG 69. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 85 FOOT ALTITUDE AND AT A VELOCITY OF 115 FT/SEC

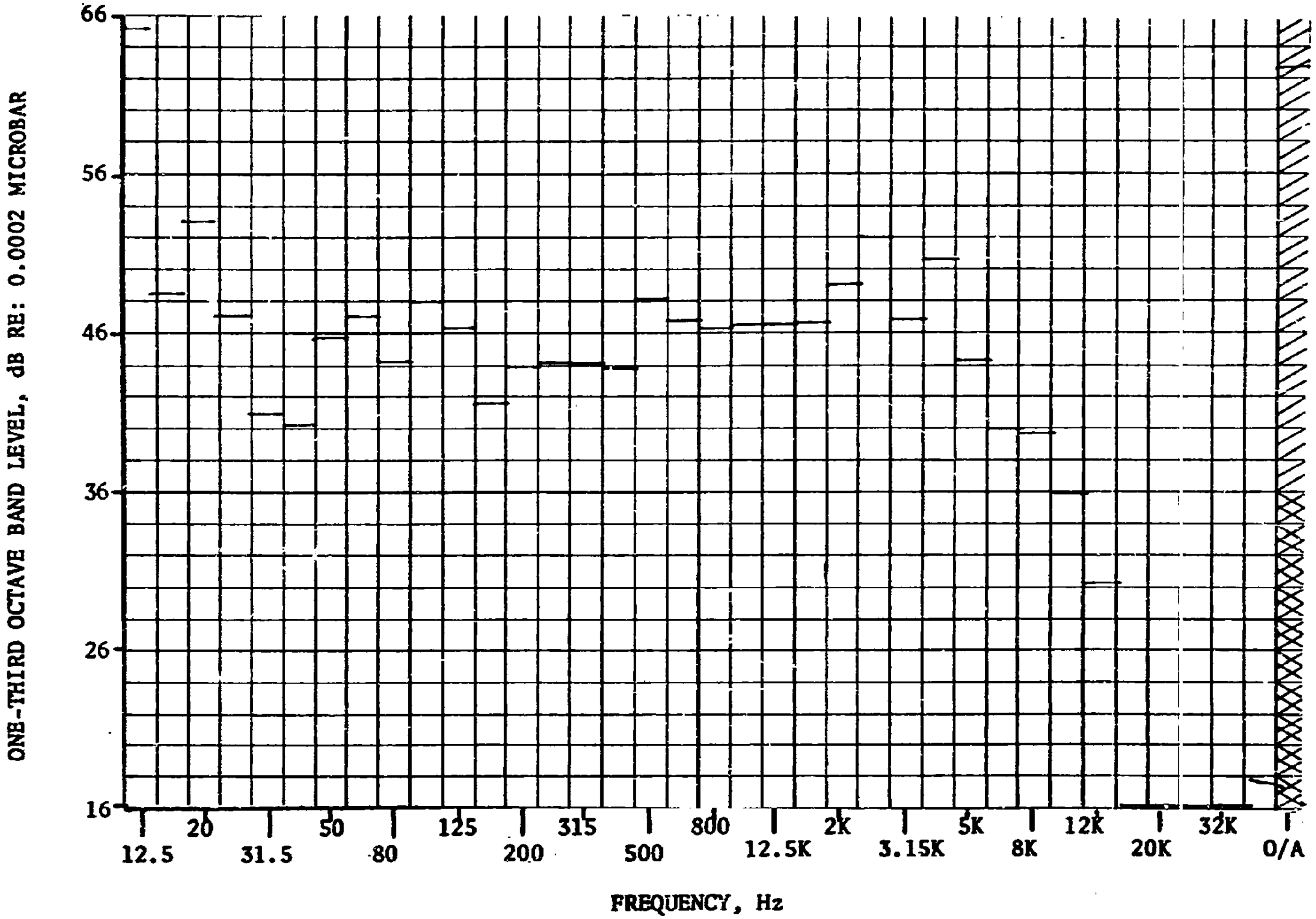

FIG 70. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 60 FOOT ALTITUDE AND AT A VELOCITY OF 140 FT/SEC

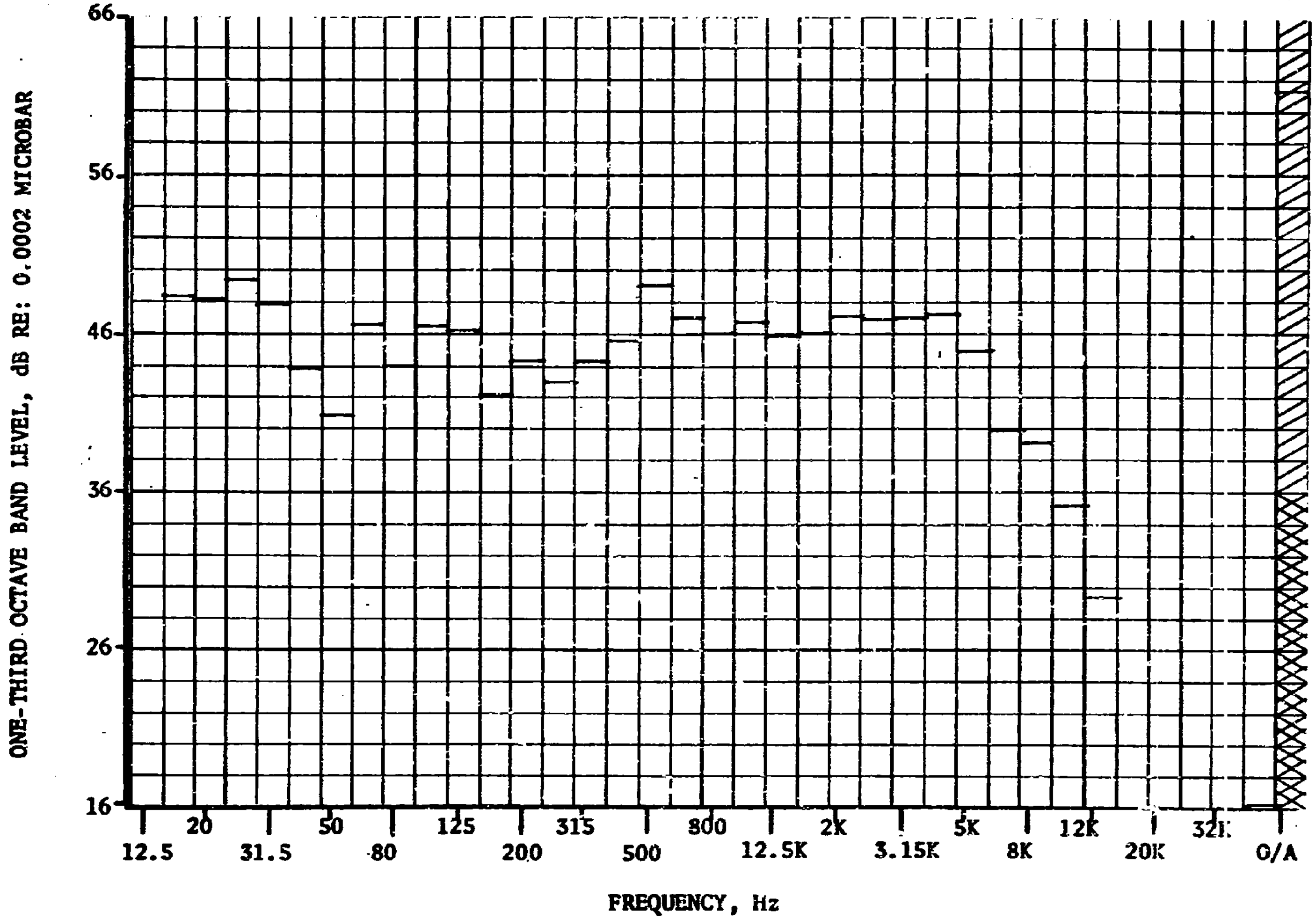

FIG 71. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 86 FOOT ALTITUDE AND AT A VELOCITY OF 158 FT/SEC

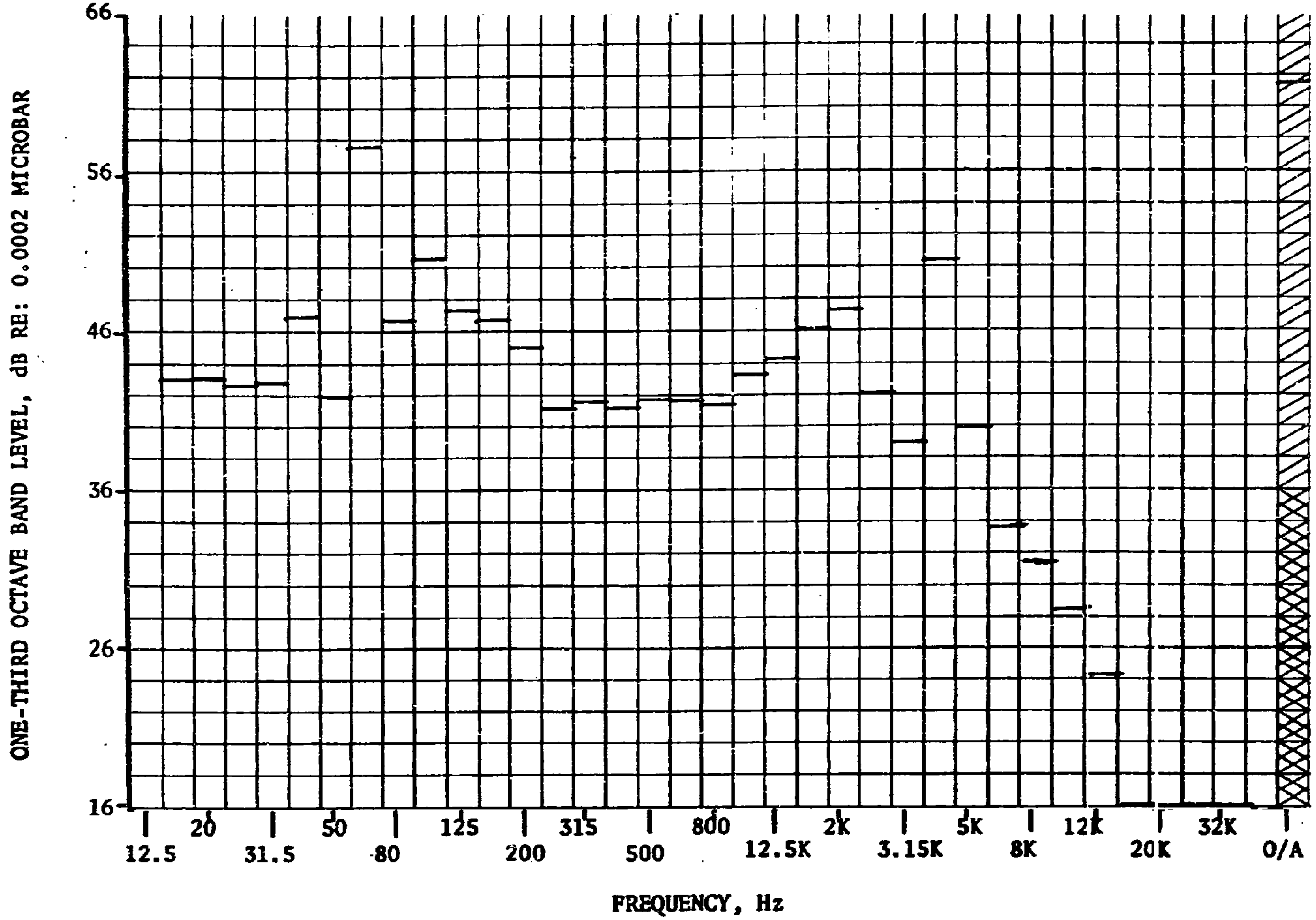

FIG 72. ONE-THIRD OCTAVE BAND SPECTRUM FROM MICROPHONE 1 FOR THE LIBELLE FLYBY AT 72 FOOT ALTITUDE AND AT A VELOCITY OF 122 FT/SEC

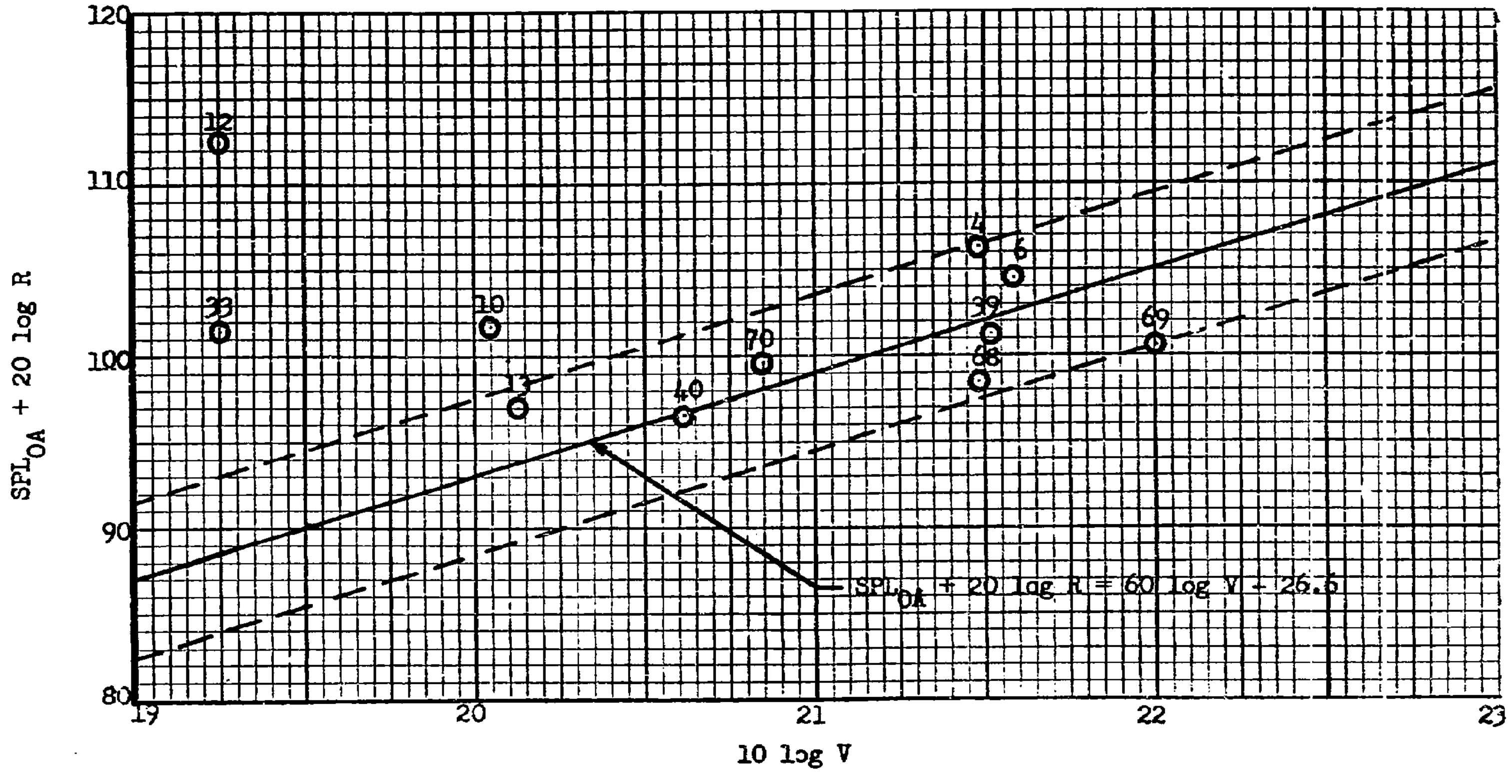

FIG 73. RESULTS FROM LIBELLE FLYBY NOISE MEASUREMENTS (MICROPHONE 1)

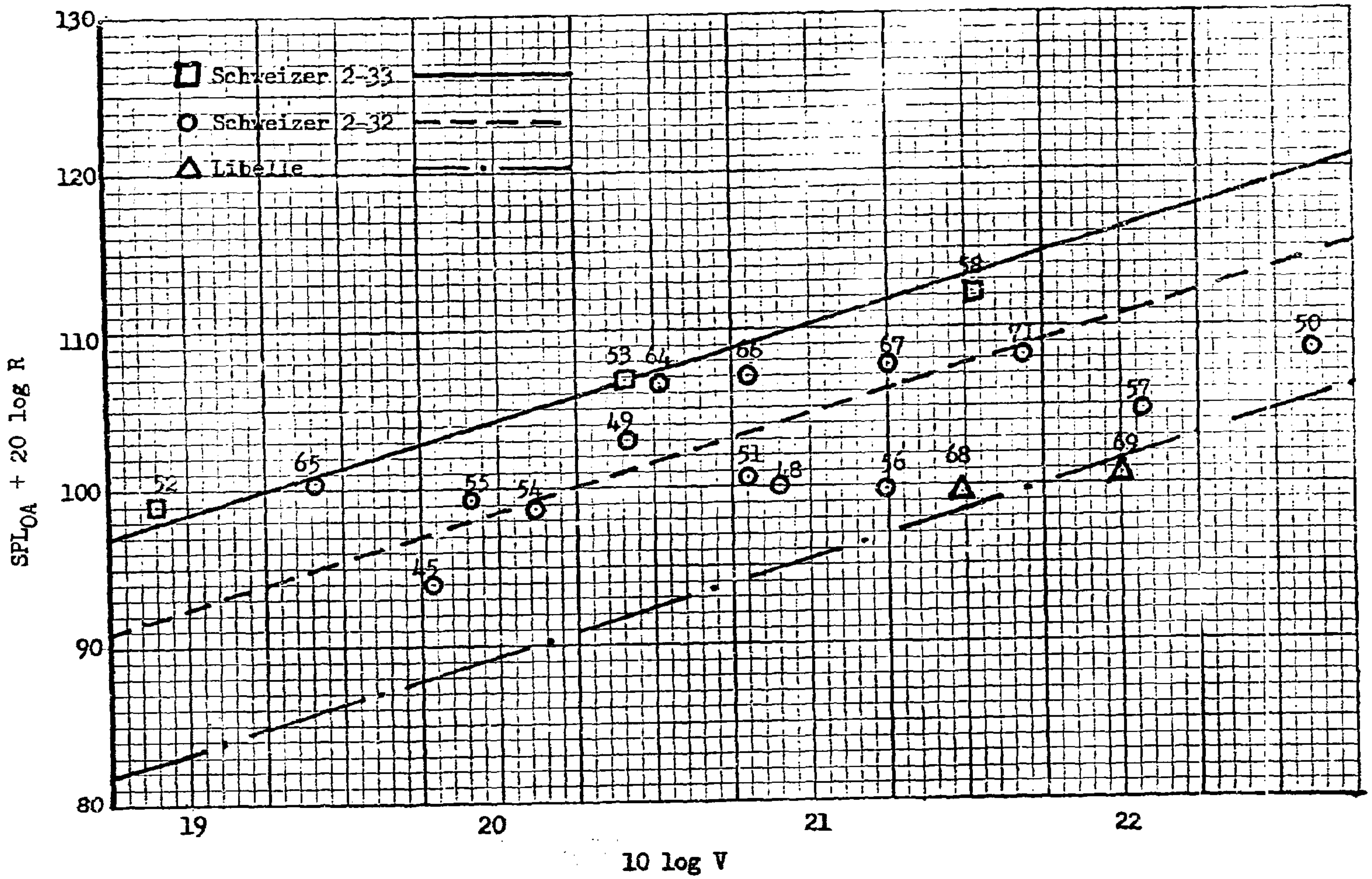

FIG 74. RESULTS FROM SAILPLANE FLYBY NOISE MEASUREMENTS USING THEODOLITE DETERMINATION OF ALTITUDE AND VELOCITY (MICROPHONE 1)

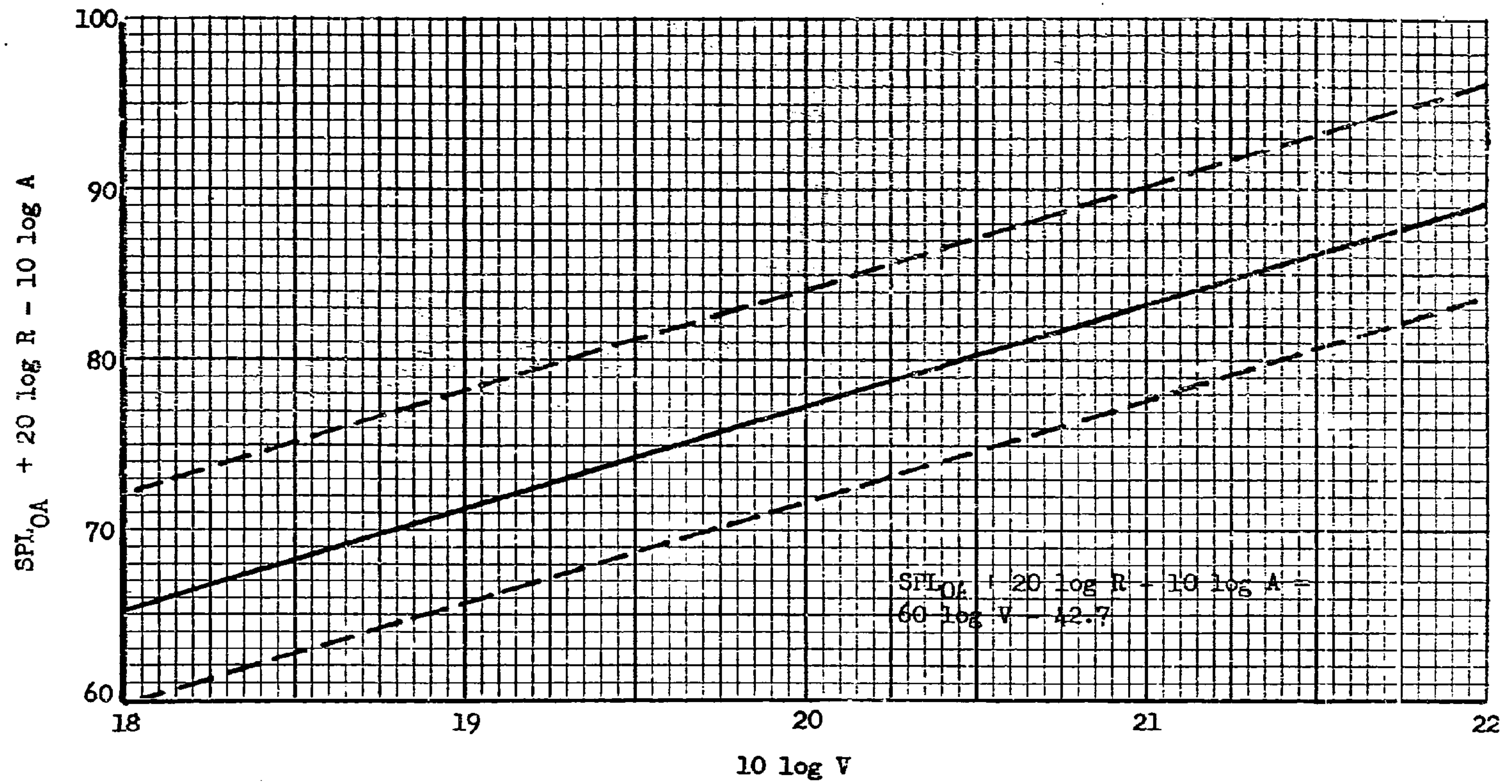

FIG 75. RESULTS FROM SAILPLANE FLYBY NOISE MEASUREMENTS CORRECTED FOR TURBULENT AREA (MICROPHONE 1)

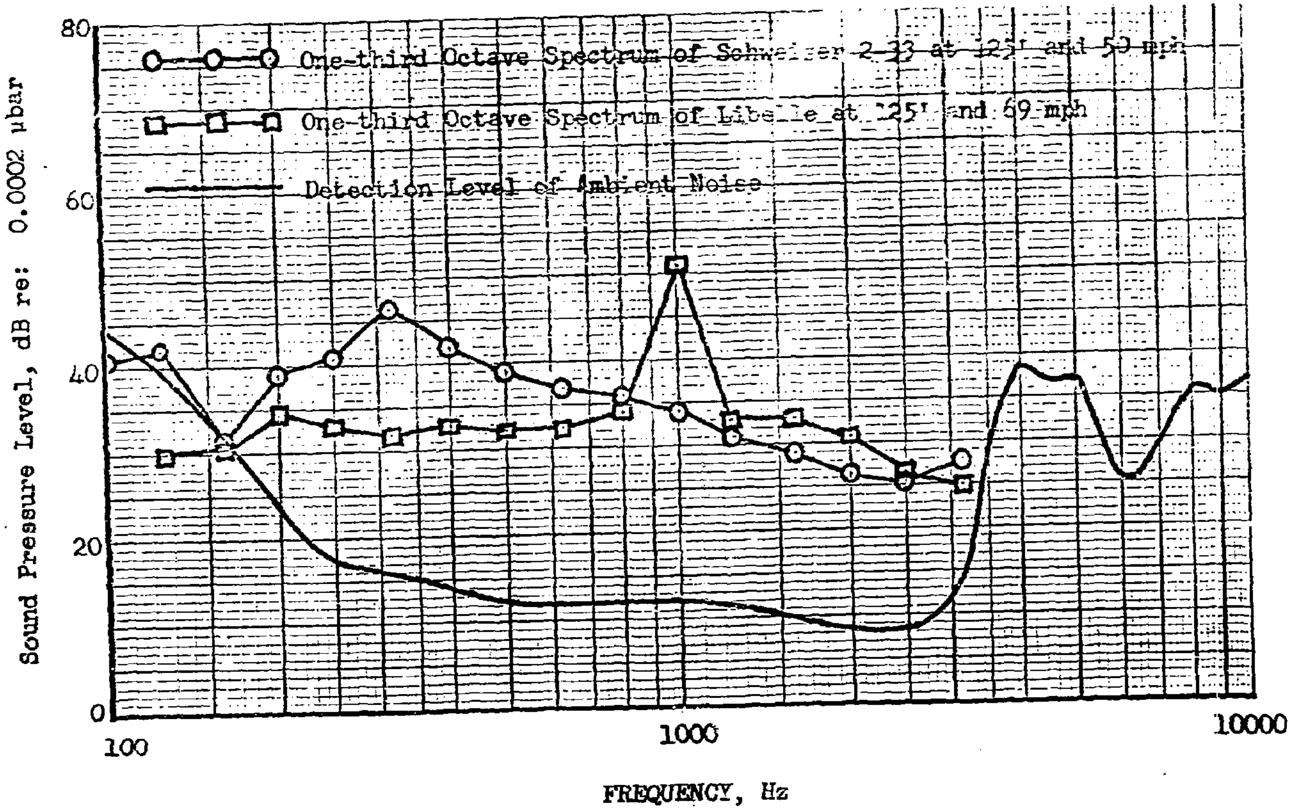

FIG 76. AURAL DETECTION ON THE SCHWEIZER 2-33 AND LIBELLE SAILPLANES

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2. Doak, P. E., "Acoustic Radiation from a Turbulent Fluid Containing Foreign Bodies", Proceedings of the Royal Society, A, Volume 254, pp 129 - 145, 1960.

3. Smith, D. L. and Paxson, R. P., "The Aural Detection of Aircraft, TM-69-1-FDDA, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, September 1969.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

The noise associated with a flight vehicle is generated by two distinct type sources; (1) the propulsion system and (2) the aerodynamic noise associated with movement of the vehicle through the atmosphere. The minimum noise will be radiated when the propulsion noise is eliminated.

Measurements were taken of the noise radiated from three sailplanes in order to define the aerodynamic noise and to determine its relation to aircraft size and velocity. This report presents the results obtained from one microphone and relates the overall sound pressure level (SPL) to aircraft parameters.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Radiated Noise from Sailplanes						
Flyby Noise						
Noise Measurements						

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